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TECHNICAL JOURNAL

GENERAL SYSTEM

APRIL, 1961 VOL. 7, NO. 6

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AUTOMATIC ELECTRIC TECHNICAL JOURNAL

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Brief description of an experimental electronic switchboard, incorporating means for interconnection with central-office trunks and equipment. It uses telephones which are standard (except for tone ringing), dial, and regular busy, and ringback tones, and it provides conference service and attendant's facilities.

P-A-B-X ELECTRONICO DE PUNTO DE CRUCE

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"SISTEMAS DE CONVENIENCIA"—SU ELECCION Y APLICACION

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THE TYPE 81A EXCHANGE-TRUNK CARRIER SYSTEM ..... **Page 213**

Lenkurt has developed a relatively simple and inexpensive carrier system which often "proves in" at distances of two miles or less, and is thus well adapted for use in expanding exchange trunk facilities.

SISTEMA DE ONDA PORTADORA TIPO 81A

La Lenkurt ha perfeccionado un sistema de onda portadora de relativa sencillez y bajo costo que en muchos casos resulta económico

WALTER AXELSEN
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aun en distancias tan cortas como de tres kilómetros y es por lo tanto apropriado para realizar ampliaciones de líneas de enlace entre centrales.

TYPE 10 INFORMATION AND SPECIAL-SERVICE DESKS . . . . . **Page 218**

Modernized desks, of two basic designs, have been designed to permit faster service on the growing volume of information and special-service traffic. For exchanges needing not more than about 50 key circuits, these desks provide "unit-mounting" and other features.

MESAS DE INFORMACION Y SERVICIOS ESPECIALES TIPO 10

Estas mesas, de estilo moderno y de dos diseños fundamentales, han sido proyectadas con el fin de acelerar el creciente volumen de tráfico de información y de servicios especiales; para centrales que no necesiten arriba de 50 circuitos de llave, proporcionan "montaje unitario" y otras ventajas.

MULTIPOINT—AN AUTOMATIC TELETYPEWRITER PARTY-LINE SYSTEM . . . . . **Page 223**

Single-party lines in teletypewriter switching systems may be converted to multi-party lines by addition of the equipment described, at each of the party-line stations. Retains all private-line service features, including full-automatic operation, and preferential handling of calls.

PUNTO MULTIPLE—SISTEMA DE LINEA COMPARTIDA DE TELEIMPRESION AUTOMATICA

Las líneas individuales en sistemas de conmutación, de teleimpresores, pueden convertirse en líneas compartidas agregando el equipo descrito a cada una de las máquinas de tales líneas. Conserva todas las ventajas del servicio de línea privada, incluyendo funcionamiento completamente automático y manejo preferente de llamadas.

REDESIGNED PUSH KEY AND TURN KEY SWITCHES . . . . . **Page 230**

Switches originally designed for mounting on thick panels have been completely redesigned to mount on thin panels, without lugs or spacers.

LLAVES DE PRESION Y LLAVES DE GIRO DE NUEVO DISEÑO

Las llaves originalmente proyectadas para ser montadas en paneles gruesos, han sido totalmente rediseñadas para ser colocadas ahora en paneles delgados, sin postes ni separadores.

AN ELECTRONIC-CROSSPOINT P-A-B-X

By R. F. Kowalik and R. P. Sanders
Automatic Electric Laboratories, Inc.

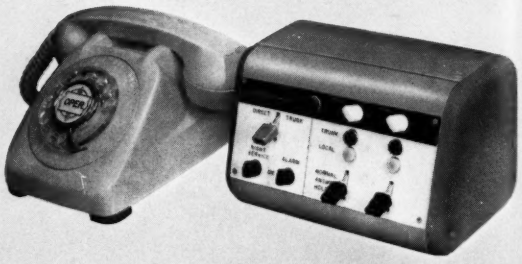


Figure 1. Attendant console of experimental electronic P-A-B-X. The developmental model has only two attendant lines equipped; a complete 100-line unit would have four lines.

A number of articles in previous issues of the Technical Journal* have reported upon Laboratories' activities in the design and development of electronic telephone switching systems—and specifically of a 100-line switchboard for isolated application. It is the hope of developmental engineers engaged in the design of electronic systems that their efforts will result in switching apparatus that is more compact and more versatile, displays better transmission characteristics, and is even more reliable than conventional electromechanical equipment.

This article will describe the operating characteristics and system organization of a 100-line electronic-crosspoint P-A-B-X which is the outgrowth of the isolated system previously described. The P-A-B-X to be discussed is currently undergoing operational testing in the Northlake laboratories.

General Features

The system is a two-wire facility in which the station instruments are Type 80 telephones, modified to accommodate tone ringing. Standard dial, busy, and ringback tones are provided. A three-digit numbering scheme is employed, wherein the first digit provides access to trunking facilities, the attendant, the meet-me conference circuit, or the block of 100 local stations. The attendant is provided with a desk-top console (see Figure 1) described below.

Local stations may of course call one another. The versatility of the exchange is demonstrated by the fact that any local party called by another local station may, at his discretion, extend the call by dialing a third local party, thus making a conference call. The third party may extend the connection to a fourth — in fact, the resulting "progressive" conference may be extended to any stations desired.

The progressive conference service is, however, limited to local calls; for trunk calls, the system features a "meet-me" conference facility, serving a group of up to six local stations and four trunks (and/or attendant lines).

Parties dialing unequipped lines are intercepted by the attendant. "Block-level" tone is supplied to any station which may dial an erroneous first digit.

**Electronic Switching—A New Concept for Future Telephone Exchanges, R. C. Stiles, General Telephone Technical Journal, January, 1959.*

A Fully Electronic Telephone Exchange, using Time-Division-Multiplex Technique, Donald K. Melvin, General Telephone Technical Journal, April, 1959.

Lossless Transmission Circuit for an Electronic Switching System, L. K. Lugten, General Telephone Technical Journal, July, 1959.

A Ferrite-Core Memory System and Distributor for a Small Electronic Telephone Switching System, P. E. Osborn, General Telephone Technical Journal, October, 1959.

Memory Devices Applicable to Future Electronic Switching Systems, J. M. Bernstein, Automatic Electric Technical Journal, February, 1960.

A 100-line Electronic Private Automatic Telephone Switchboard, John G. Van Bosse, Automatic Electric Technical Journal, April, 1960.

Trunk Facilities

Twenty trunk lines to an electromechanical central office are provided—ten 2-way-dial trunks and ten PBX trunks. All of these are available for outgoing calls. The two-way-dial trunks permit in-dialing to any of the P-A-B-X stations. These trunks emanate from a level of a fifth selector, and access the electronic system via a trunk repeater. Thus, the first five digits dialed by a subscriber would control the central-office equipment, and the last two digits would be acted upon by the P-A-B-X and would be used to seek out the particular called party from within the block of 100 local subscribers.

The PBX trunks access the electronic exchange via a trunk-hunting connector. Incoming calls over these trunks are directed to the attendant by the control networks of the electronic system. Because only four attendant lines are envisioned, and because there may be as many as ten PBX trunks requiring service, a camp-on-busy feature is provided.

A desk-top attendant console providing control and supervisory facilities not available to regular stations was designed. A subset similar to those in use by local stations can be associated with any of four operator lines by manipulating a three-position (normal, answer, and hold) key. A trunk lamp and a local lamp associated with each line not only alert the attendant to incoming calls but indicate the source of the call. Flashing lamps always demand action by the attendant; steadily burning lamps indicate the status of connections in which the attendant is engaged.

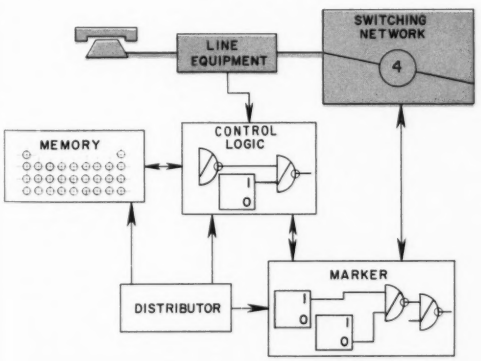


Figure 2. System Block Diagram. The functional relationship of the various subdivisions of the system is depicted above. The symbols within the blocks labeled "Control Logic" and "Marker" indicate that these areas are logic networks employing the "nor" function.

A turn key associated with each line allows the attendant to access the meet-me conference facility without dialing; thus any party or trunk to which the attendant is connected may be provided access to a meet-me conference. A conference lamp burns steadily whenever local stations associate themselves with the meet-me conference, and flashes if the local lines disconnect, leaving an attendant line alone associated with it. At the attendant's discretion an audible alarm may be actuated when the lamp flashes.

Facilities are provided so that any local party (or the attendant) may transfer the trunk to which he is connected to any other local party (or to the attendant) by simply dialing the station or attendant number; the trunk is silenced during this phase of a transfer, but when the attendant or the transferring party hangs up, an audio connection is restored between the trunk and the remaining local station. The attendant uses this feature to route incoming PBX trunk calls to appropriate subscribers. The number of times a trunk may be transferred is not limited.

During the transferring operation, normal supervisory signals are returned to the attendant or local party that initiated the action. In the event the called party should fail to answer or is busy, the transferring party may revoke his action and, by dialing a special digit, restore the speech path to the trunk.

To provide an active termination for PBX trunk calls during periods when an operator is not in attendance, a night-service feature is available. The operation of a turn key on the attendant cabinet will route incoming calls to preselected local stations.

Trunk restriction on selected lines is provided; restricted parties attempting to access trunks are routed to the attendant for service.

System Organization

Logical Networks

Electronic telephone switching systems are, in effect, digital computers designed to perform a specific task; they employ computer techniques and circuitry, and may be subdivided into functional blocks similar to those of computers.

Figure 2 presents the organization of the 100-line electronic-crosspoint P-A-B-X in block-diagram form. The switching network performs

the all-important function of providing a variety of audio paths through which stations may carry on conversations with one another. Each party has a line equipment which provides him an audio link to the switching network. This circuit also contains sensing elements which report the status of the subscriber's line loop: open (on hook) or closed (off hook). Strapping options on his line equipment determine class-of-service restrictions applicable to each party.

This system deviates from step-by-step operation in that all information concerning a call is assembled before any steps are taken to establish audio paths. The control logic is a decision-making logic network that interprets the fluctuations of the station line-loop current caused by dialing and hook-switch manipulation, and assembles information pertinent to user action. When sufficient information has been received, the control logic demands that the marker perform the required activity. The marker is another logical network that regulates the establishment and destruction of audio paths within the switching network.

Time-Sharing

Since a control logic is a rather extensive network, it is economically impractical to assign one to each subscriber. Instead, one control logic is made common to all stations and is shared by time-division techniques; that is to say, each station in turn is exclusively provided the facilities of the network for a short (123 microsecond) period of time, on a cyclic basis.

Considering trunks, operator lines, and meet-me conference lines, as well as local stations, there are in all 130 lines which must make use of this network in turn; after a given line uses the network, the other 129 lines must be served before that line may again use the network. The result is a 16-millisecond (130 times 123 microseconds) cycle. Information assembled and decisions made during the 123-microsecond period of logic network usage by a given line must not be lost, but must be retained and presented to the control logic early in the next reviewing period of that line.

For this storage, each line is provided a binary word in a ferrite-core memory. The memory word consists of 31 binary digits or "bits"; it is read at the beginning of each reviewing period and the revised information is placed in the memory near the end of the reviewing period.

Many of the activities of the system, such as the time-sharing of the control logic, require a time reference. This reference is established by a pulse-train generator called the "distributor". Two of the pulse trains produced are of interest (Figure 3). Ten "tens" pulse trains are generated, each consisting of a 1600-microsecond pulse with a recurrence rate of 16 ms. The trains are designated T_{D1}, T_{D2}, T_{D3}—T_{D0}. The pulse of T_{D1} is followed by that of T_{D2}, etc., T_{D0} being followed by T_{D1}.

Within each tens pulse is included a complete series of units pulses. There are 13 units pulse trains (U_{D1}, U_{D2}, U_{D3}—U_{D0}, U_{DX}, U_{DY}, U_{DZ}), which appear sequentially. Each units pulse is of

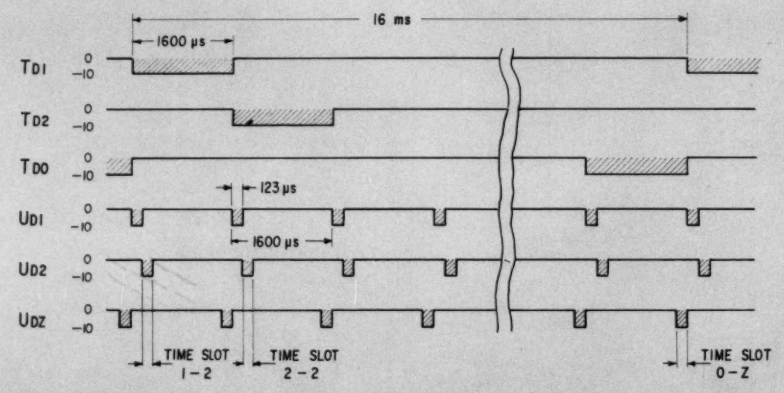


Figure 3. Distributor pulse trains. Portions of "tens" and "units" trains are shown. Time-slots (one of which is assigned to each line) are generated by the simultaneous occurrence of "tens" and "units" pulses.

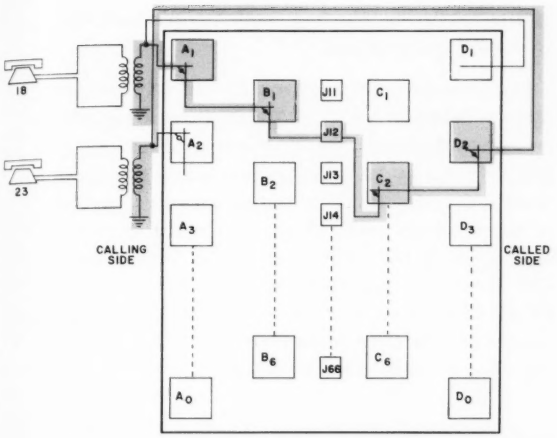


Figure 4. Crosspoint switching network showing subscriber 18, calling party, connected to subscriber 23, called party, via junctor 12. Calling party uses A and B matrices while called party uses C and D matrices.

123 microsecond duration and recurs every 1600 microseconds. Each time-slot is designated by the simultaneous occurrence of a tens pulse and a units pulse. This scheme results in 130 time-slots, one of which is assigned to each of the 130 lines in the system. The time-slot is the reviewing period during which a station is afforded the services of the control logic.

Transmission Network

The transmission network of the electronic P-A-B-X is composed of an array of 32 interconnected crosspoint matrices and 36 junctors. The junctors are used to join the two symmetrical halves of the network.

The matrices are of two types; the "originating-terminating" (O.T.) type are the matrices to which the station line equipment is connected, and the "intermediate" (I) matrices are used to connect the O.T. matrices to the junctors.

Figure 4 is a skeletonized block diagram of the entire transmission network. The O.T. matrices are designated A and D and the I matrices B and C. In this exchange, as in its predecessor, a connection via the transmission network originates at an A matrix, proceeds to a junctor via a B matrix, then leaves the junctor via a C matrix and terminates at a D matrix. Thus a network requirement is that each line be represented by equipment on both sides of the network: at an A matrix, where it may originate calls, and at a D matrix, where it may receive calls.

As in the earlier switchboard, the crosspoint device used here is the PNPN silicon diode. Figure 5 illustrates a portion of the circuitry used to establish a connection between any two stations. We shall review it quickly, since it is almost identical to that described in a previous article.*

When the marker has determined that a connection between two subscribers is required, and that the called subscriber is not already engaged in a call, it seeks out a path between the matrices, over which the call may be routed. As soon as a possible path is found, the crosspoint elements forming the path are marked with a negative

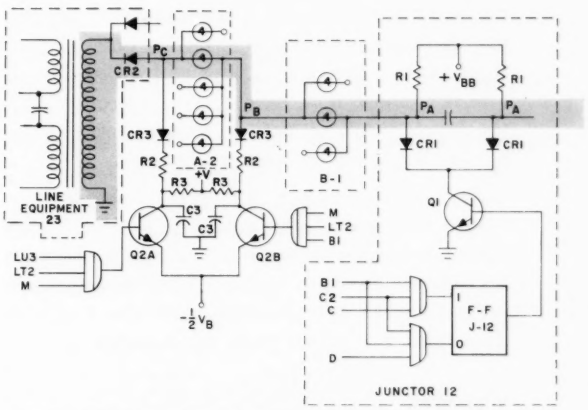


Figure 5. Portion of switching network, showing the circuitry necessary to establish a d-c connection between a line equipment and one side of a junctor.

potential on their cathodes; this operation, called "link-marking", is accomplished via transistors Q2A and Q2B (Figure 5). The marker next causes the junctor connecting the two selected I matrices to present a rising positive potential to its output terminals. In Figure 5, the potential rise is accomplished by switching transistor Q1 to its cut-off state. The rising positive potential causes the crosspoints in the I matrix to break over into its conducting state. Then, as the capacitor in the link-marking circuit charges positively, the crosspoint in the O.T. matrix reaches its break-over voltage and it switches into its conducting state. The capacitor in the O.T. link-

*A 100-line Electronic Private Automatic Telephone Switchboard, John G. Van Bosse, Automatic Electric Technical Journal, April, 1960.

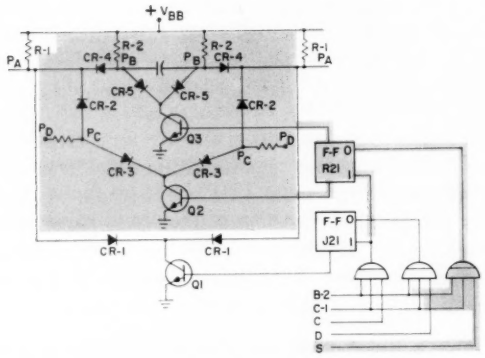


Figure 6. Junctor circuit, showing the complete junctor circuitry required to control both ringing and ringback tones and the source of the positive switching voltage required by the crosspoint elements.

marking circuit now charges positively, finally causing the diode connecting the line equipment to the O.T. matrix to be forward-biased. Since the same marking and crosspoint-fixing process has simultaneously occurred on the other side of the junction, both the calling and called sets of line equipment now have a d-c connection into the junctor. An a-c path is formed between the junctor terminals by a large capacitor.

Conversation could begin, but it would be subject to heavy shunt losses via the link-marking circuit. In order to avoid this, once the d-c path is established, the link-marking circuitry is returned to its idle condition and this source of shunt loss is removed from the connection.

Signaling

Thus far, a d-c path has been established between each station line equipment and one side of the junctor, and further, an a-c connection has been provided across the junction; before conversation can begin, however, the called party must be informed that someone wishes to talk with him. In an electromechanical P-A-B-X, standard ringing current and ringback tone are sent to the called and calling parties, respectively. In an electronic P-A-B-X, however, using currently available semiconductor components, the voltage and current levels required to activate the standard ringer are simply beyond reach. This exchange, therefore, uses an electronic ringing signal—an interrupted audio tone that actuates an audio oscillator in the telephone; the oscillator output is coupled to a receiver capsule mounted in the telephone housing, and the receiver acts as the signaling device.

Supervisory tones are also required, and because this exchange is a P-A-B-X and these tones will go out over the trunks, they are made to sound like the tones to which the subscribers have become familiar. In order to minimize the number of circuits required to place the ringing and ringback tones at the calling and called telephones, it was decided to gate them onto the talking circuit at the junctor rather than at the line equipment, since the only time these tones are required is at the time a connection is completed.

Signaling Circuitry

Figure 6 shows the additional junctor circuitry required to add ringing and ringback tone to the system (transistor Q1 will not be discussed, for it is the same Q1 already discussed as part of Figure 5; it is shown here for information only). The additional circuitry consists of an additional AND gate (required to address an added flip-flop, used to control ringing), transistors Q2 and Q3, and a group of diodes and resistors. Ringing tone is applied at point P_D on the side of the junctor connected to the called side of the network; ringback tone is applied to the same point on the other side of the junctor. (Placing the tones on the line is accomplished by diverting the tones from ground to the junctor output.)

With transistor Q2 saturated, diodes CR-3 are forward-biased and the tones appearing at points P_C are clamped close to the ground. To make the tones available at P_A, transistor Q2 is cut off, removing the ground from diodes CR-3 and permitting points P_C to rise towards +10 volts. This, then, forward-biases diodes CR-2, and the tones are available to the crosspoint network.

Preventing the tones from being transferred across the junctor is accomplished by reverse-biasing diodes CR-4. Normally when it is desired to disable the audio connection across the junctor, the points P_A will have a positive potential in excess of +2.5 volts. By saturating transistor Q3, the potentials at points P_B are clamped close to ground, and diodes CR-4 are reverse-biased. A requirement here is that the value of resistors R2 be sufficiently small that the diodes of CR-4 will operate in a linear portion of their characteristics when they are required to carry the audio signals.

This article was based on four papers delivered by Automatic Electric engineers at the 1961 Winter General Meeting of the AIEE:

J. G. Van Bosse—Features of an Electronic Crosspoint P-A-B-X

R. F. Kowalik—Transmission Network of Electronic Crosspoint P-A-B-X

R. P. Sanders—Logical Control of an Electronic Crosspoint P-A-B-X

J. P. Shuba—Philosophy of Design of the Ferrite-Core Memory for a 100-line Crosspoint P-A-B-X

Copies of these papers are available; please address requests to the editor.

The over-all operation of the tone gates is as follows. Initially, in the idle state, transistor Q2 is saturated and transistor Q3 is cut off. Flip-flop R21 is in its reset state.

The same command from the marker which arrives to set F-F-J21 also sets F-F-R21. As the connection is being established, transistors Q2 and Q3 have changed states as controlled by F-F-R21. Points P_C are released from ground, permitting the tones to propagate to the connected line circuit, while points P_B have been clamped to ground, suppressing all transmission across the junctor. The junctor is now in its ringing state. After some time, either the called party has answered the call or the calling party has abandoned it. In either case the marker generates a signal (S) which requires the ringing flip-flop to be reset. The signal (S) is combined with the address of the junctor in an AND gate whose output is used to reset F-F-R21. The flip-flop changes state, returning Q2 and Q3 to their original states. Points P_C are clamped to ground, reverse-biasing diodes CR-2. Points P_B are released from ground, and rise until diodes CR-4 become forward-biased. Points P_B will settle out at some voltage related to the potential at points P_A plus the drop across diodes CR-4. The tones are now not coupled to the talking path, and the subscribers are free to speak.

Conclusion

The switchboard described in this article demonstrates the technical feasibility of electronic switching in a system that is trunk-connected to a public telephone network; it is, of course, but one of many possible approaches to the problem. The future of electronic switching depends upon developments such as this, and other developments that will reduce the cost of the electronic components needed. We may well expect that electronic switching will become economically as well as technically feasible for commercial telephone service.

Richard P. Sanders (left) joined Automatic Electric in 1958 as a participant in the graduate engineer training program. In this program he worked in a number of departments before joining the research department in the Laboratories. He has since been engaged in the design of electronic switching systems. Mr. Sanders graduated from the Purdue University school of electrical engineering in 1955.

Ronald F. Kowalik is a graduate of the University of Illinois (February, 1958) with the degree B.S. in E.E. He joined the staff of Automatic Electric Laboratories immediately after graduation, and began working on applications of electronic switching for the telephone industry. He has done design and development on electronic line-concentrators, as well as on the switchboard described in this article. Mr. Kowalik is a member of I.R.E.

"CONVENIENCE SYSTEMS"—
Their Selection and Application

By George R. Bradley, Jr.
Automatic Electric Company

Today, when a business subscriber requests a particular communication service, the telephone man often has a variety of facilities to choose from which will, in one way or another, provide the service desired. He then has the problem of selecting the specific apparatus that will best meet the subscriber's requirements, with proper regard to other factors involved. This article is intended to outline some of the factors that should be considered in various situations, to provide the most effective installation at lowest cost. The apparatus discussed will include key-type telephones, small P-A-X's, relay-type key telephone systems, Secretarial-Answering service, and executive quick call units.

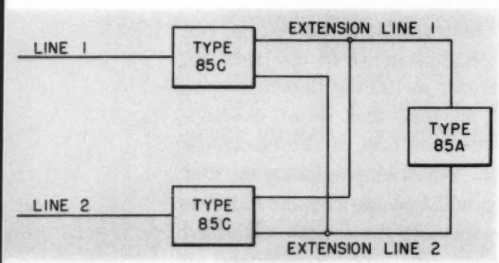


Figure 1. Two or three individuals have access to each of two lines in this typical network for three Type 85 telephones in a business organization.

Pick-Up on Two Lines

The simplest problem of this kind (see Figure 1) occurs where two central-office lines are required in a business organization, and it is desired that two or three individuals have access to each of the lines. Type 85 telephones (described in a previous article)* meet this specific requirement with simple keys (see Figure 2) that provide for two-line pick-up, with signaling if desired. This type of network, however, provides no holding feature nor visual signaling.

*Three New Special Service Telephones—Automatic Electric Technical Journal, October, 1959.

Pick-Up and Hold on Two or Three Lines

Where call-holding is required, the Type 87 telephone would be used (see Figure 3); it provides for holding on each of three lines, and in addition provides visual as well as audible signaling. A number of Type 87 telephones can be multipled to three central-office or private branch lines, in essence giving service similar to a small switchboard (see Figure 4). Each of the three Type 87 telephones can be equipped with an exclusion key which may be wired to one of the lines, and, when operated, will provide complete privacy to the station on the particular line. The ringer of each Type 87 telephone may be wired to this same line, thus giving each station essentially a private line, yet with facilities for answering calls on the other lines, and holding them, if

Figure 2. Type 85 telephone provides for two-line pick-up, with signaling if desired, to meet specific requirements.

Figure 3. Type 87 telephone provides for holding on each of three lines, also affords visual and audible signaling.

necessary, to answer other calls. (In this arrangement, one set of ringers is normally sufficient for all telephones, since at each phone a visual indication is given when a particular line is rung.)

Two Lines and Intercom

If an organization requires two stations to have access to two central-office or branch lines, and also desires intercommunication of a limited nature, Type 87 telephones can again be used. A possible arrangement, utilizing two Type 87 telephones and a number of standard telephones, is illustrated in Figure 5. In this application, the central-office lines are lines 1 and 2, and terminate only at the two Type 87 telephones. The local intercommunication line, which connects to all of the standard telephones, is normally line 3 of each Type 87 telephone. This line is a common talking path and no privacy can be provided.

In order to signal between stations on this line the nonlocking signal key of the Type 87 telephone is used. Each telephone on the line is assigned a code. A buzzer which is mounted externally at each telephone provides an audible signal recognizable to the station being called. A battery eliminator or other low-voltage power source is required to provide the necessary talking battery and current for signaling on this intercom circuit. The standard telephones multipled to this line require a special nonlocking push key for signaling.

Intercom and Trunk Service for 10 Stations

If, in the organization just described, it had been desired to give all stations (up to 10) access to the central-office trunks, Type 87 telephones could be used, in conjunction with the Type 85 P-A-B-X, which is a wall-mounting unit, 14½" square by 5½" deep. The Type 85 P-A-B-X provides for two central-office trunks and ten local stations. All ten local stations can be arranged

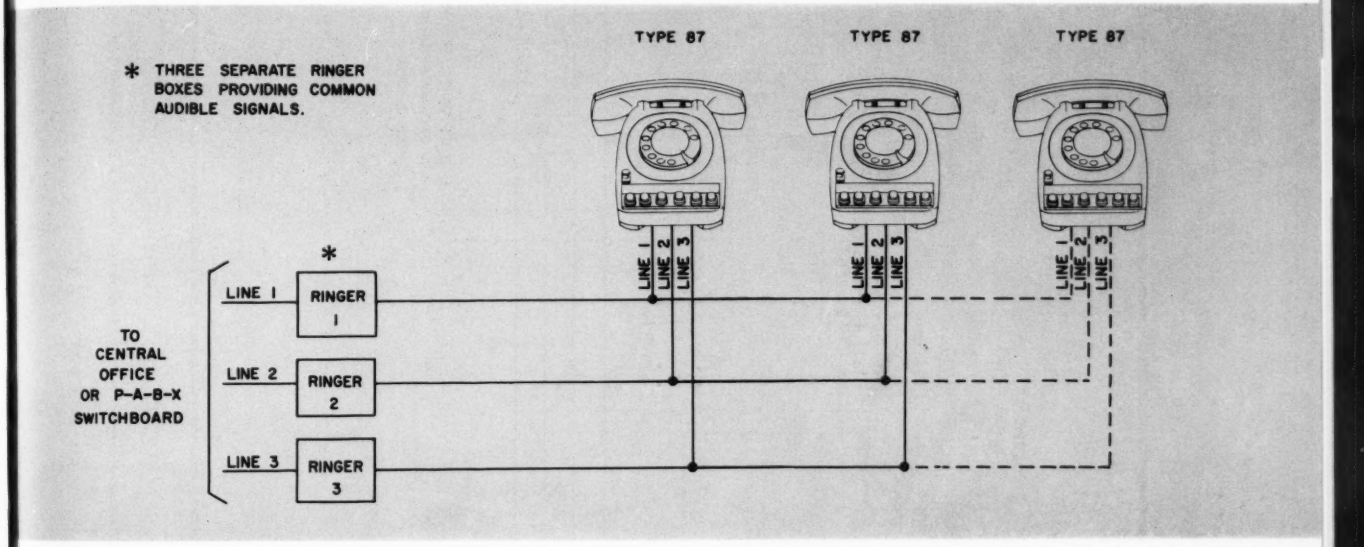


Figure 4. A three-line network using Type 87 telephones reveals their use for service similar to a small switchboard for either central-office or private branch lines.

to access both central-office trunks, and each station can call any other by selective dialing. In this arrangement, also, the intercom service is common-talking.

One station may be arranged to have Secret Service on both central-office trunks. This means that full privacy is available to that station by merely operating the exclusion key in conjunction with the pick-up key associated with the trunk being used. As in the previous example, the ringers on the central-office trunks are common to all stations having access to the trunks. Talking battery and ringing current on these trunks is provided from the central office. Power (12 volts d.c.) for selecting and signaling on the local line is provided by a battery eliminator, operating from 105/125-volt, 60-cycle commercial a.c. (This

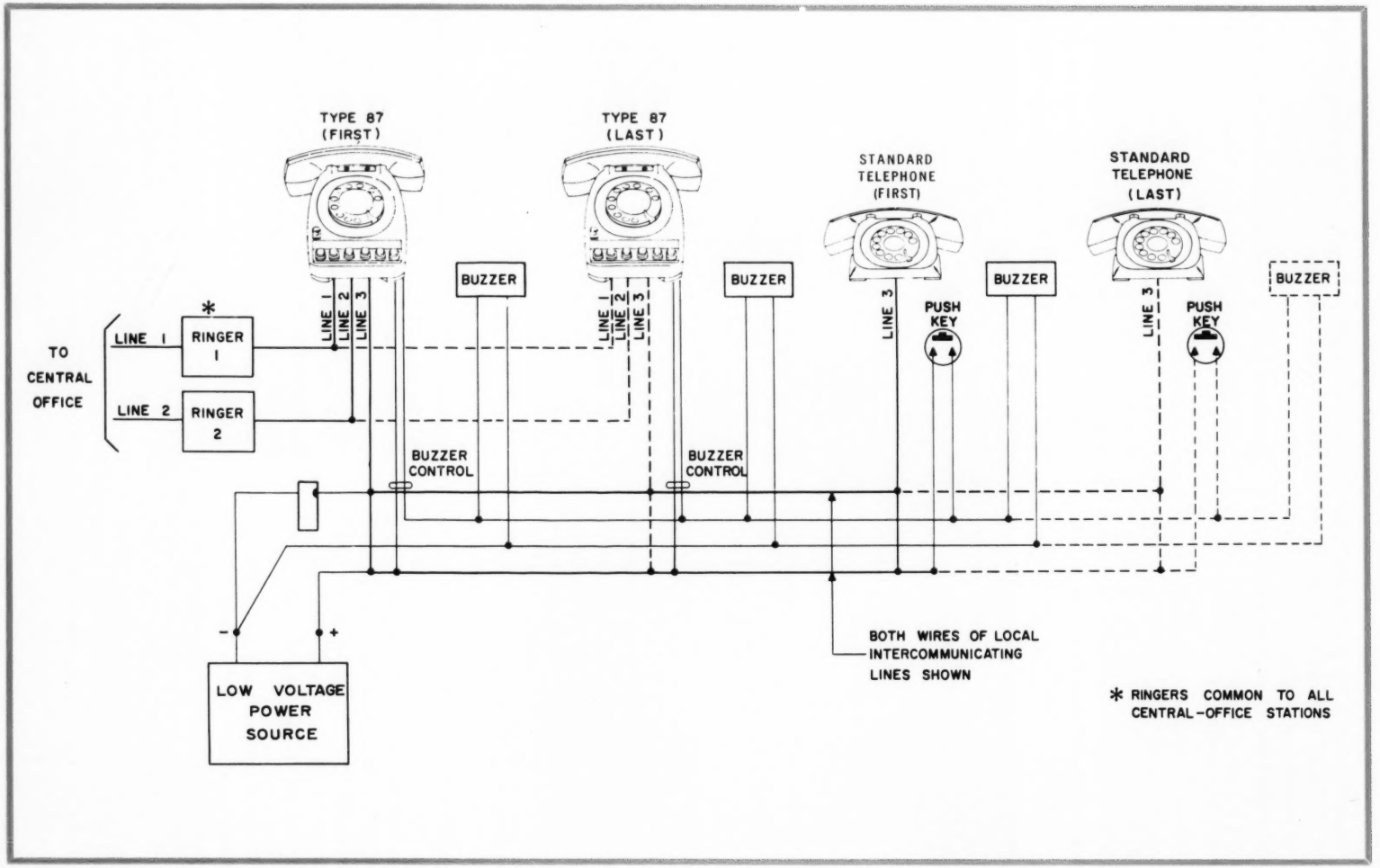


Figure 5. In this network two Type 87 telephones arranged with a number of standard telephones allow for two central-office lines and one intercom line with local code signaling.

battery eliminator is a part of the Type 85 P-A-B-X.)

Figure 6 illustrates this use of Type 87 telephones in conjunction with the Type 85 P-A-B-X. All of the Type 87 telephones have access to the central-office trunks and the local intercom line, while the standard telephones have access only to the intercom line. Only the first Type 87 phone has Secret Service available on the central-office trunks.

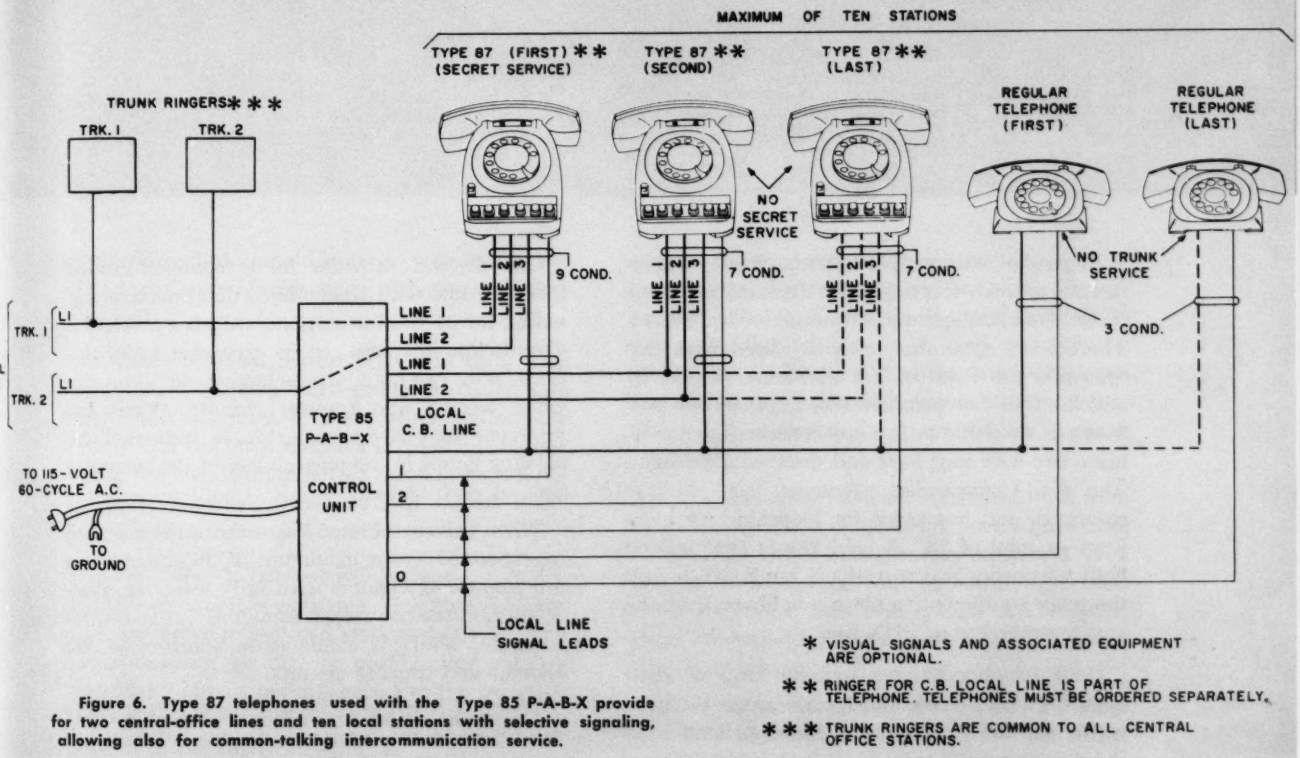


Figure 6. Type 87 telephones used with the Type 85 P-A-B-X provide for two central-office lines and ten local stations with selective signaling, allowing also for common-talking intercommunication service.

A call received on a central-office trunk at any Type 87 phone can be held by operating the associated hold key; additional stations may then be called, or desired information obtained, over the intercom line. The central-office call can then be re-entered by reoperating the line pick-up key.

A Comprehensive "Convenience System"

For organizations requiring more than ten telephones, or a wider range of services, there is the Type 10A1 Key Telephone System.* Using "Call-Commander"** telephones (Figure 7), this system can provide access to up to 17† central-office or PBX lines, and can provide intercom service between 36 stations, with a varying degree of features. Normally the majority of the stations will each have access to the central office via a varying number of lines, depending on the importance of the station and the instrument used. This system is suitable for many medium-size businesses that desire complete telephone service both via the central office and within the local organization. No attendant is required to handle calls to and from the central office or PBX.

**Expanded 10A1 Key System—Automatic Electric Technical Journal, July, 1960.*

***"Call-Commander" is a registered trademark of Automatic Electric Company.*

†A station in a Type 10A1 Key Telephone System equipped with a "Call-Commander" telephone can have access to 17 central-office or PBX lines, or may have fewer central-office lines and be able to signal many intercom stations via push button.

Figure 7. "Call-Commander" telephones in a comprehensive convenience system provide access for up to 17 central-office or PBX lines and intercommunication service between 36 stations with a variety of features.

In general, this system consists of relay equipment (centrally located at the organization being served), station apparatus, and power equipment. The station apparatus primarily used with this system is the Type 86 key telephone (Figure 8) and the Call-Commander. The Type 86 key telephone is available in five key-combination assemblies, two with four keys and three with six keys. The Call-Commander telephone has 12 keys equipped, and has space for mounting six more keys—a total of 18. A hold key is available on both telephones and it works in conjunction with the relay equipment to place a hold condition on any central-office or PBX line.

Both telephones have pick-up keys of clear plastic which are equipped with lamps for indicating the line condition. A flashing lamp indicates an incoming call, while a steadily lit lamp indicates a line which is busy or being held. If the optional winking circuit is used, a winking lamp will indicate the line is being held. The pick-up keys of the Call-Commander can all be converted to manual-signaling keys, while on the Type 86 key telephone only those prearranged can be converted.

The heart of the Type 10A1 key-telephone system is its intercom, comprising a number of assemblies which can be arranged basically in three ways:

One method provides for a common-talking intercom line with single-digit, dial-selective signaling for up to nine stations, utilizing a selector circuit; this intercom can be expanded to 18 stations with two-digit, dial-selective signaling, by using selector and transfer circuits. When the intercom line is in use, this is indicated by glowing lamps in the pick-up key of the intercom line, at each station.

When privacy is required or the intercom is to be expanded (to a maximum of 36 stations), a private-talking channel with fully selective, dial- or pushbutton-controlled signaling (or a combination of both) is available in addition to the selector and transfer circuits.

Third, if it is desirable to have a better grade of service on the intercom, the two-talking link can be used instead of the single private-talking channel; this permits two completely private conversations to take place at the same time. The two-talking link also employs fully-selective dial or pushbutton-controlled signaling (or a combination of both). An optional feature with the

Figure 8. Type 86 key telephone, having five key-combination assemblies available, is used with the type 10A1 Key Telephone System.

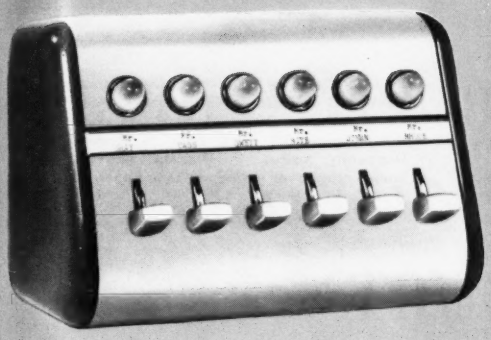


Figure 9. Secretarial-Answering Service: With a six-line unit, shown here, one secretary may answer and hold calls on a half-dozen lines, lines that may also be individually connected to the central-office or to a P-A-B-X.

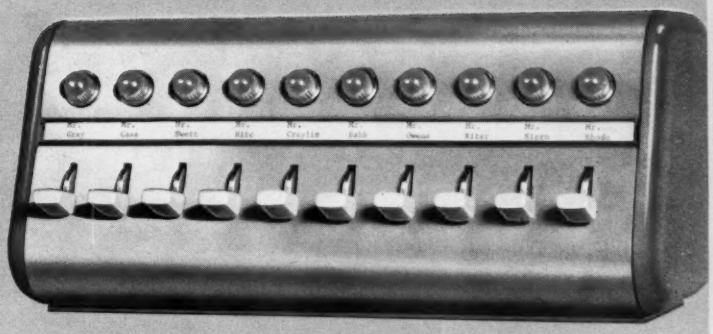


Figure 10. Secretarial-Answering Service: These units (the ten-line unit is shown here) have each line associated with a three-position lever key (Release, Answer, and Hold) and a neon lamp.

two-talking link provides busy tone when the called station is already busy with another intercom call.

Another optional feature is "camp on". With this feature, when a busy station is dialed and busy tone is returned, the calling station can "camp" on the busy station's line until it is free. When the busy station is free the station is automatically signaled. Other stations cannot interfere with this camp-on connection.

In addition to the above features, a preset conference circuit is available. This circuit allows up to six other preselected stations to be signaled simultaneously by dial or push button. Also a "long-line" circuit permits access to the intercom by a station located an unusually long distance from the other intercom stations.

Secretarial-Answering Service

Another convenience which can be offered to a business organization is Secretarial-Answering Service. This compact unit will allow one secretary to answer and hold calls on six, ten, or twenty lines, depending on the size of the answering unit being used (the six-line unit is shown in Figure 9, the ten-line in Figure 10, and the twenty-line in Figure 11). Associated with each line is a three-position lever key and a neon lamp. The three lever-key positions are Release, Answer, and Hold.

If an organization has six individual lines from a central office, or a department has six lines from a P-A-B-X, these lines can be connected to a Secretarial-Answering Unit in addition to their primary stations. This Unit is ideal in a situation where the individual parties are frequently away from their telephones.

When an incoming call is received, the lamp associated with the line flashes, while the ringer sounds at the called station. If the call is not answered at the called telephone, the secretary can answer the call by operating the associated lever key to the Answer position. This will connect the secretary's telephone to the line. When several parties are away from their telephones at once, only one call can be connected to the secretary's telephone at one time, but several calls can be held for handling.

An optional feature of the Secretarial-Answering Service is an Audible Signaling Unit, which gives the secretary an audible as well as a visual signal when a line is rung.

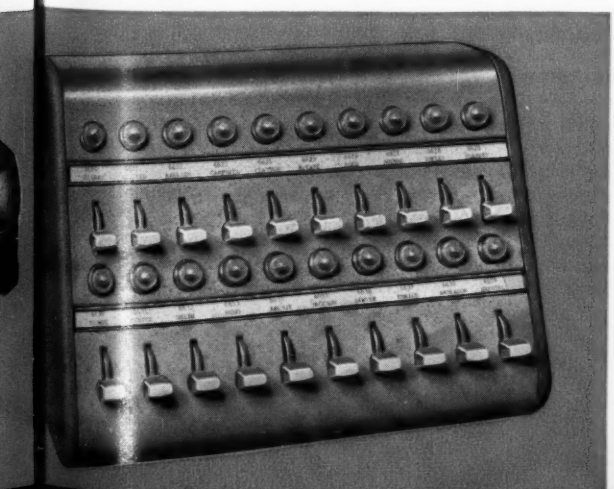


Figure 11. Secretarial-Answering Service: As in other units, the 20-line unit shown here allows the secretary to connect to 20 lines when parties are away.

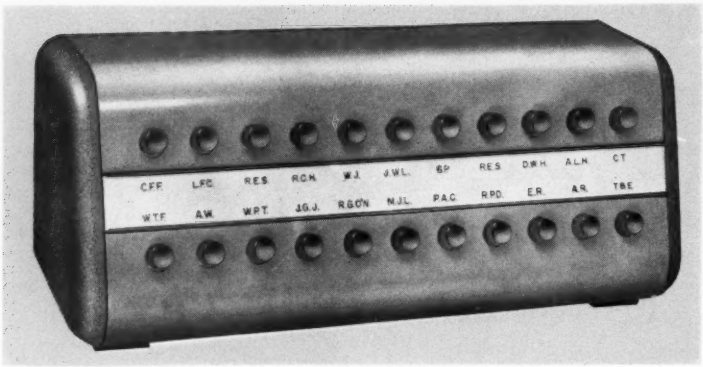


Figure 12. The time-saving executive quick call unit shown here connects into the regular P-A-B-X equipment and gives the executive 20 direct lines to stations frequently called, functioning with a Speakerphone or standard telephone.

Executive Quick Call Unit

For an executive of a rather large organization, the executive quick call unit (Figure 12) is a real time-saver; it connects into the regular P-A-B-X equipment and provides the executive 20 direct lines to stations frequently called. The equipment consists of a cabinet containing 22 nonlocking push buttons, and an associated relay group. The Unit will function in conjunction with either the standard type of station instrument, or with a loudspeaking telephone, and its use does not affect normal P-A-B-X service.

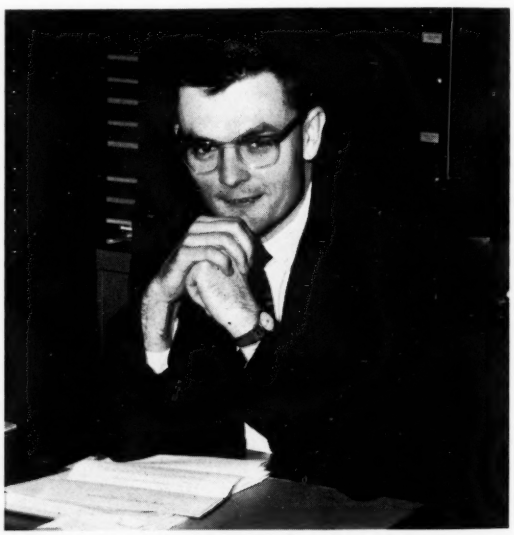
The executive is able to call any of the 20 direct line stations by pushing the correct button and lifting the handset of the telephone (or turning it on). If the line is idle, the called party's telephone automatically rings. If the line is busy, the executive can hang up—or, by pushing a "tone" button, can place a distinctive tone on the called party's line, indicating that the executive is waiting. The called party, upon completing his call, is connected immediately to the executive.

Should the executive choose not to interfere with the existing conversation, he may "camp" on the line. Then when the party has completed his conversation he will be connected directly with the executive. On the other hand, if the executive needs to talk to the busy party on an urgency basis, he can push the "cut-through" button and connect to the busy line.

On central-office calls, the executive can hold the call while he initiates a direct-line call. The "hold" feature permits the executive to contact a direct-line station, yet be immediately reconnected to the central-office party, on retiring from the direct-line call.

Summary

The many services through modern "convenience systems" make it possible for the telephone company to meet a wide range of business needs. The telephone man who is familiar with these systems, the services they offer and their relative cost, is in a position to secure maximum benefit from them.



George R. Bradley, Jr., received his B. S. degree in Industrial Education from Purdue University in 1955. He spent two years in the Navy as a Lieutenant, j. g., joining Automatic Electric in July, 1957, as a technical writer. He became Technical Publications Supervisor in the Engineering Department in November, 1958. While in Technical Publications, Mr. Bradley prepared and supervised preparation of literature covering the selection, installation, and maintenance of the many new types of telephones introduced during recent years. He is now Manager of Engineering, Planning, and Services in the same department. Mr. Bradley is a member of the Society of Technical Writers and Editors.

THE TYPE 81A EXCHANGE-TRUNK CARRIER SYSTEM

By M. R. Dunning
Lenkurt Electric Co., Inc.

In their search for better and cheaper ways to expand local plant, engineers are turning to exchange-trunk carrier equipment. One of the main problems, however, has been to reduce the economic prove-in distance to below the former minimum of 15 miles, since, in the independent telephone companies, 94 per cent of all trunks are less than 15 miles long.

Aside from considerations of cost, carrier offers many transmission advantages over voice-frequency circuits. On spans which are too short to require repeaters, there may be considerable level variation between circuits; voice-frequency repeaters provide a means of controlling transmission levels, but this may be their only justification on short trunks. Not only does carrier provide this same control over attenuation—permitting transmission levels to be independent of the length or nature of the circuit—but it also provides many additional high-quality circuits at low cost.

A special advantage of modern exchange carrier is its flexibility in expanding plant to meet new circuit demands. As cable circuits become filled, carrier systems can be added one by one as the need arises. This provides a means for orderly expansion, even in areas where demand has not

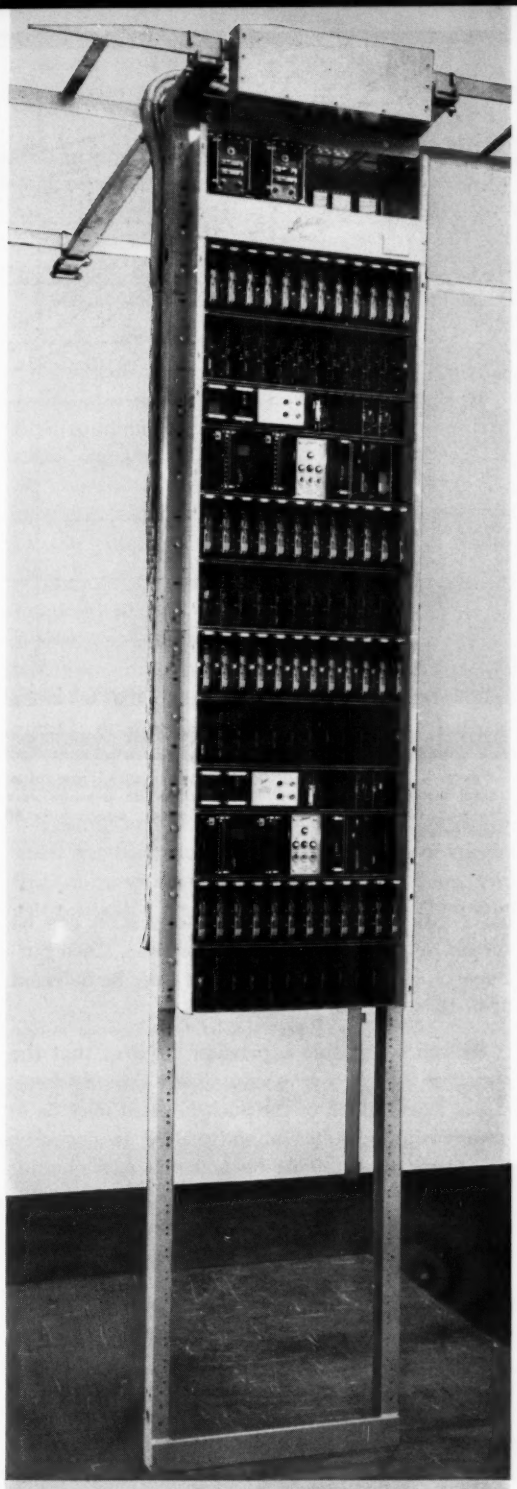


Figure 1. Type 81A Exchange-Trunk Carrier System equipment (front view) mounted in the switchroom. This system has proved-in on circuits of less than 2 miles. Two 24-channel systems are shown.

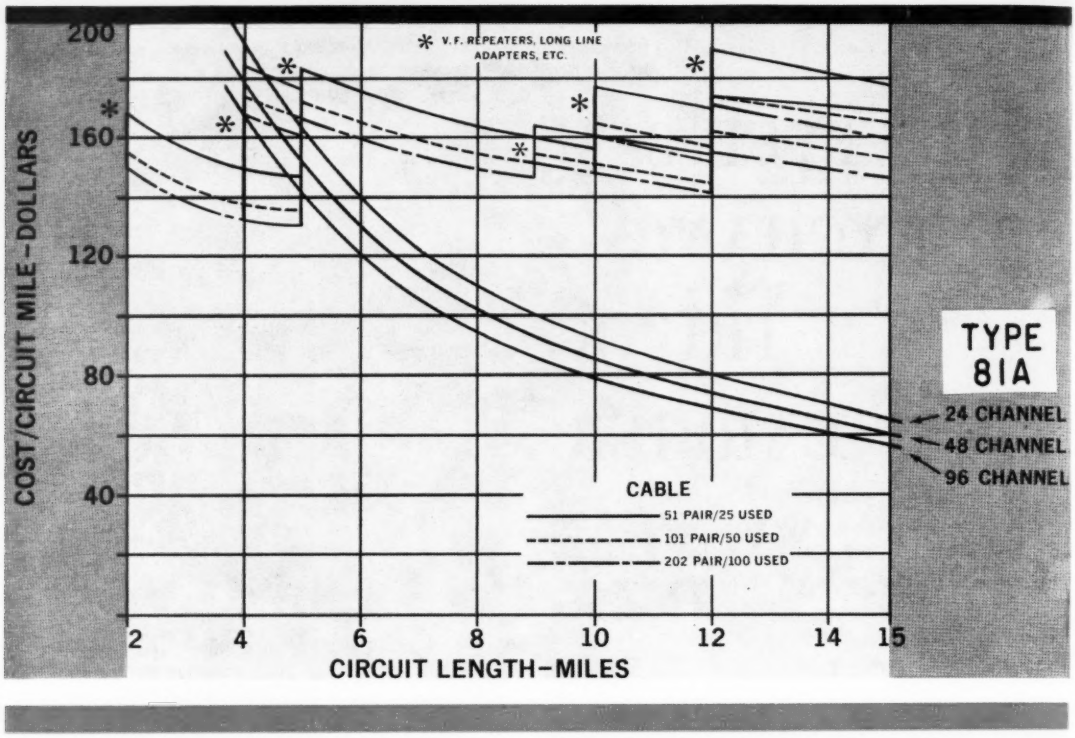


Figure 2. Proved-in costs are compared with those of several commonly-used types of cable in this chart. Cable costs show total installation and material, based on an average value of 125 per cent of material, and include v-f or trunk repeaters suitable for the distance indicated. Carrier costs include all equipment, repeaters, and installation based on 140 per cent of equipment cost.

been anticipated. The cost of expansion can be spread out over a long period of time, since purchase of channelizing equipment may be deferred until it is needed.

By contrast, cable expansion requires that the entire expenditure be made at one time. In large cities, where much of the outside plant may be in underground conduit already filled to capacity, streets may have to be opened and new conduit added. Some cities sharply restrict how often this may be done. Or, large-gauge cable may be replaced with smaller-gauge cable, but this process cannot be continued indefinitely because the smaller cable degrades transmission; eventually, more conduit and cable must be installed, or additional circuits must be obtained by using carrier.

In suburban areas and between small towns, where aerial cable is almost universally used for trunks between exchanges and switching offices, there is little problem—particularly with the newer light-weight cables—in adding circuits as demand grows. Under these circumstances, carrier systems are usually competitive only when they can provide the additional channels at a cost lower than that of new cable and its accessory equipment, other factors being equal.

Recently, Lenkurt engineers have met this challenge with an exchange-trunk cable-carrier system (Figure 1) that has proved-in on circuits of less than 2 miles. Figure 2 shows the economic prove-in curves for the Lenkurt Type 81A Exchange Trunk Carrier System as compared with several commonly used types of 22-gauge cable.

Application

Lenkurt Type 81A equipment is used to transmit up to 24 voice-frequency channels over two cable pairs, in the frequency spectrum of 21.3 to 402.5 kc. It is designed as a short-haul trunk carrier system for use between two central offices, with an optimum range of 15 miles over 22-gauge aerial cable. Because of crosstalk coupling and repeater power feed considerations, however, system length is normally restricted to less than 15 miles.

A typical Type 81A equipment application is shown in Figure 3. Trunks adaptable for Type 81A operation are shown by a dotted amplifier

symbol. In this application, Type 81A equipment is used for all trunks except the intertoll trunks between the primary toll outlet and the Alto and Mateo toll centers.

Figure 4 shows how Lenkurt Type 81A equipment can be used to expand existing facilities between central offices. By using Type 81A equipment, 24 channels can be operated over the same 2 cable pairs previously assigned to v-f trunks using trunk repeaters—and the trunk repeaters can be eliminated. In this case, the trunks shown are one-way dialing trunks from the HUdson 7 central office to the EMpire 6 central office. The Type 81A equipment is arranged for outgoing loop dial signaling at the HUdson 7 office and for incoming loop dial signaling at the EMpire 6 office. No incoming or outgoing trunk repeaters are required.

Mechanics

An integral part of the system design has been the introduction of transistors and plug-in "card-type" construction. With this technique, components are mounted on circuit boards which plug into a shelf, as shown in Figure 5. In production of the boards, tin-coated bronze staples are inserted at desired locations; each staple becomes the termination for one or more nearby components, mounted on the other side of the board, and for bare-wire connections to other staples. All component leads and connecting wires are wrapped firmly around the staple ends before soldering, to provide excellent mechanical and electrical connections.

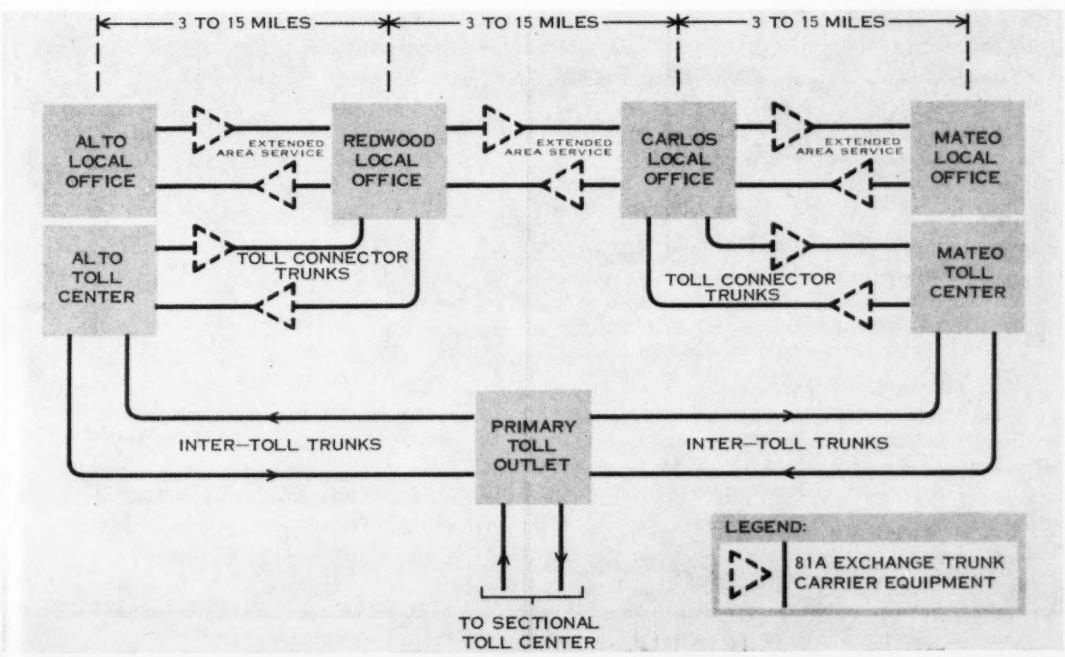
Economies realized through the use of these techniques have helped reduce the cost of Type 81A equipment without cutting quality. "Card-type" construction also saves space—for example, 96 channels of Type 81A equipment, including power and signaling equipment, can be mounted on one standard 11'6" relay rack, 19" in width.

The use of transistors results in a lower power requirement and less heat dissipation. Telephone carrier equipment normally uses vacuum tubes, which require separate sources of filament and plate battery. Lenkurt Type 81A carrier equipment is powered entirely by 48-volt office battery.

Maintenance

Testing and maintenance of Type 81A equipment has been simplified by the design of special test equipment and maintenance instructions. Two self-contained test sets are used. The Terminal and Repeater Test Set is used to make all meas-

Figure 3. This block diagram shows an actual and typical application of Lenkurt Type 81A Exchange-Trunk Carrier System equipment.



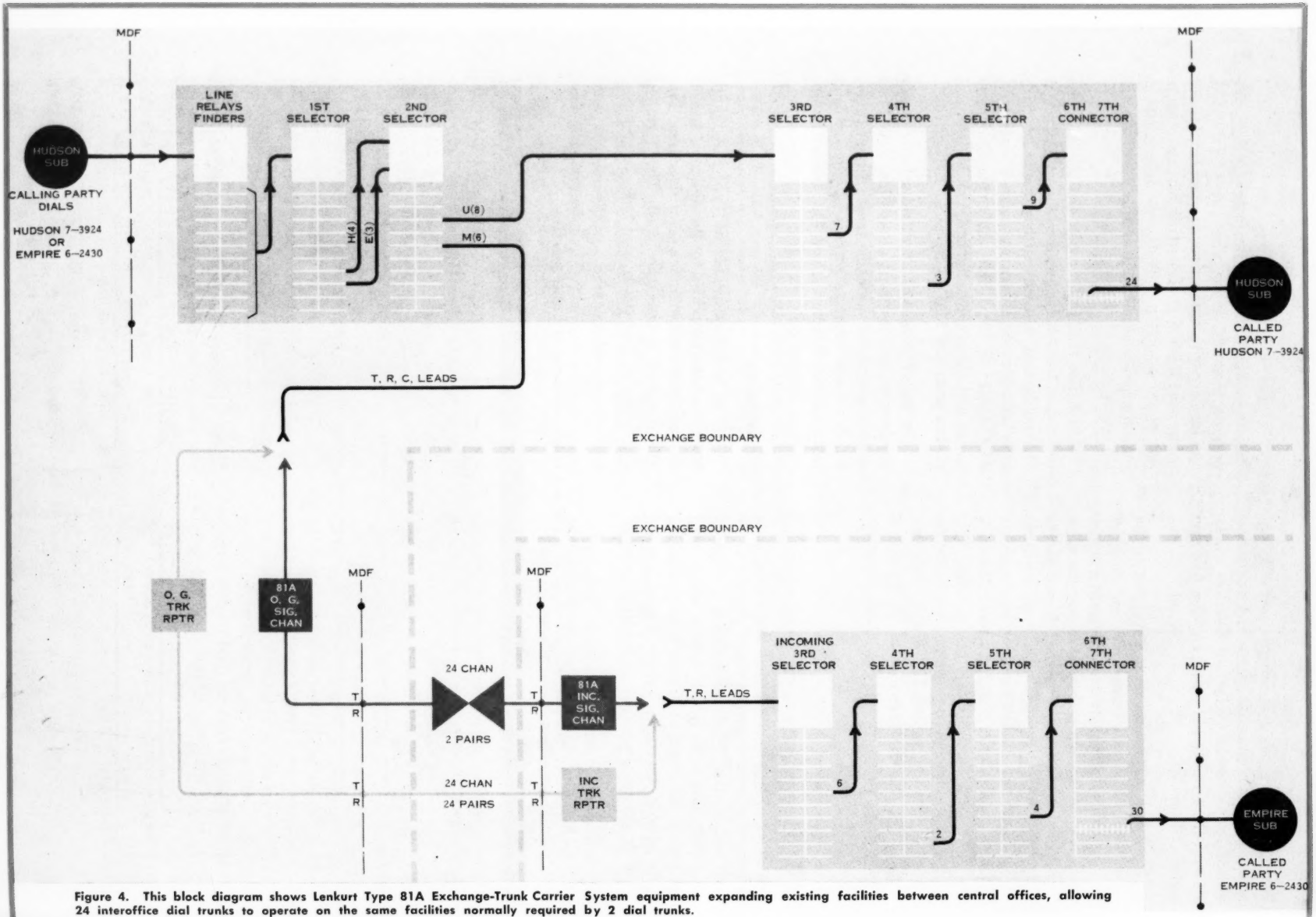


Figure 4. This block diagram shows Lenkurt Type 81A Exchange-Trunk Carrier System equipment expanding existing facilities between central offices, allowing 24 interoffice dial trunks to operate on the same facilities normally required by 2 dial trunks.

urements in the high-frequency circuits. It has been designed so that a cable splicer may use it in a manhole or on a pole to make all necessary repeater adjustments. The V-F Test Set includes an audio oscillator with a fixed output level, and a meter for voice-frequency adjustments.

Lineup and maintenance instructions have been simplified. Tables and figures show the test equipment connections, adjustment controls, and meter readings. Other instructions have been written for use by personnel trained in the repair of Type 81A equipment. These instructions are complete, with voltages and wave-forms of the unit circuits where applicable, and are designed to simplify the job of repairing defective units.

The plug-in "card type" mechanics permits instant replacement of any unit that is in trouble. The "stitched wiring" of the units allows easy replacement of damaged or defective components, and also reduces the chance of failure due to poor solder joints, rough handling, or vibration.

An optional Spare Carrier Line Facility and Patch Panel is also available to assist in locating and restoring to service failed cable pairs or repeater circuits. The panel includes a complete working spare carrier line, including repeaters. Each end of the spare carrier line facility appears at a jack field, along with the carrier lines of all working systems. The spare carrier line can be used to replace, by means of patch cords, a failed cable pair (including repeaters) of a working system. Then the failed portion of the circuit can be repaired at a more convenient time.

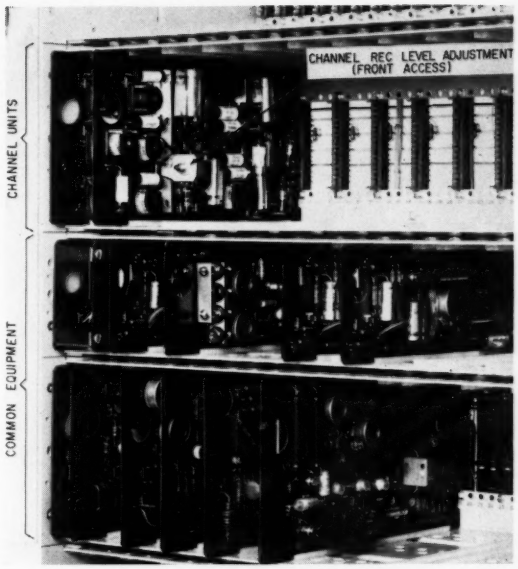
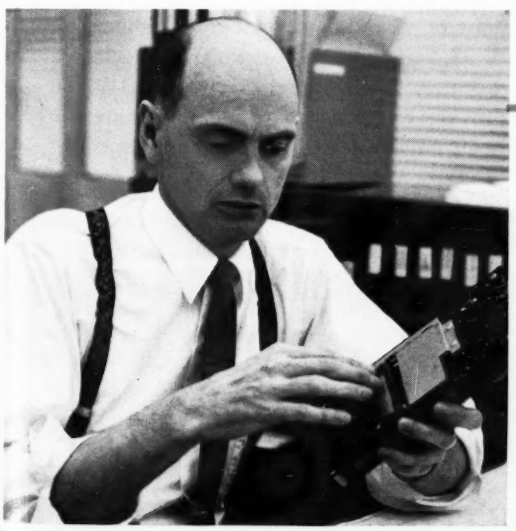


Figure 5. Lenkurt Type 81A terminal shelf, front view, depicts variety of plug-in units and methods of mounting and connection through the multicontact sockets at the rear of the shelf.

Summary

Lenkurt Type 81A Exchange Trunk Carrier is a step forward in improving transmission quality and providing a tool with which telephone companies can supply better service at lower cost.



Milton R. Dunning's career in communications and electronics began with the Navy during World War II when he served as a shipboard radio and radar specialist. Following that, 12 years as central-office equipment installer and installation supervisor with Western Electric Company were especially fitting training for his subsequent work. He joined Lenkurt in 1959 as Engineering Writer. In this assignment he has prepared many specifications on installation of various types of multiple channel carrier equipment. Most recently he has written the technical literature covering theory, installation, and operation of the Type 81A Exchange Trunk Carrier System, described above.

TYPE 10 INFORMATION AND SPECIAL-SERVICE DESKS

By B. Mandarino
Automatic Electric Company

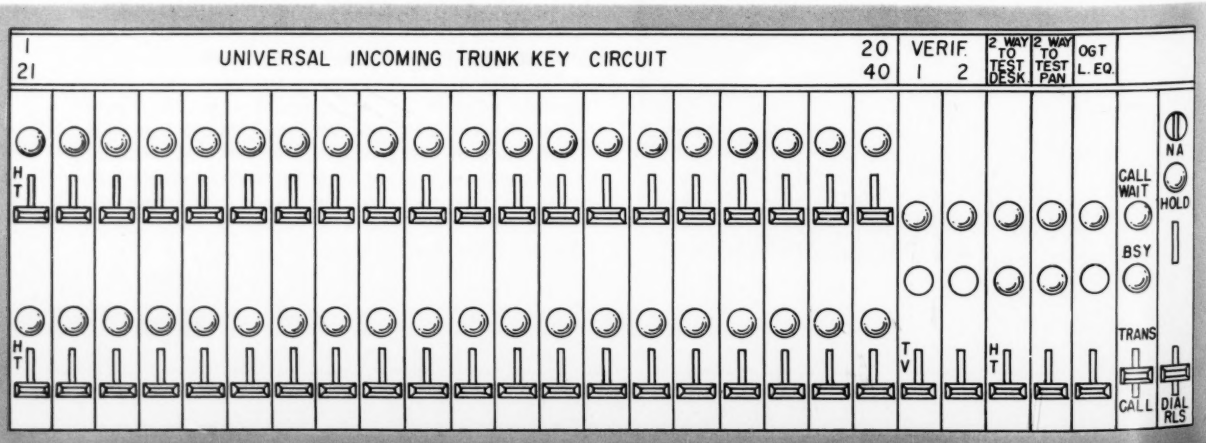
Figure 1. Type 10B Information and Special-Service Desks, as shown here growing from left to right in a typical floor plan layout, are used with directory books or Buchan files; a variation of the floor plan layout (with Position 2 about-faced and half-adjoining Position 1) is used when rotary files are required. Note that Position 1 has two additional jacks for supervisor's use.

While the trend to DDD has lightened the traffic load on toll positions, it has *increased* the need for Information, Rate and Route, Verification, and other operator special services. Type 10 Desks have therefore been designed to facilitate these services in telephone exchanges too small to justify use of our Type 3 Desk. They incorporate features introduced a few years ago in our Type 31 toll board—including Class B relays with twin contacts, and "unit-mounted" circuit equipment mounted on a separate relay rack. They permit fast and efficient service in exchanges needing not more than about 50 key circuits.

Design and Construction

Where information is stored in rotary files, or in certain types of Buchan files, the cabinet generally used is the Type 10B (shown in Figure 1). This is manufactured in one-position units only, and is a single-sided cabinet of such depth that the files are readily accessible to the operator. The keyshelf layout (see Figure 2) provides for 40 incoming and 5 outgoing (or two-way) universal key circuits; any number of cir-

Figure 2. Keyshelf layout for Position 1 of Type 10B Information and Special-Service Desk; in Position 2, the turn key in upper right is designated "TRANS" instead of NA".



cuits can be supplied, up to the ultimate. Note that the keyshelf is slightly depressed, so the key handles are entirely below the level of the cabinet top, and are not likely to be accidentally moved. The cabinet is 2′-6″ wide, 3′-1″ deep, and 2′-6″ high.

Where book-type information directories are employed, the cabinet used is the Type 10A, which may be supplied either single- or double-sided (see Figures 3 and 4), to adapt the equipment to the floor space available. A sloping surface at the front of the desk furnishes convenient space for the directories, while the key panels containing the trunk key and lamp equipment, along with the dial, and special-purpose keys, are mounted nearly vertically above the sloping desk top. Each section is assembled on a rigid, welded, angle-iron frame. If a number of sections are bolted together to form a continuous line-up, adjacent operators are separated by transparent plastic baffles. End panels are provided for only two ends of the line-up.

Each section is 3′-7½″ high (not including plastic baffles) and 3′-2″ wide. A single-sided section is 3′-1″ deep; double-sided, approximately 5′-0″. A cable-turning section is not required, as the first section of the desk can be set over a cable hole if the cables go through the floor. Or, the installer can cut a hole in the end-panel on the "nongrowing" end, if the cables are to be overhead; in this case, cable-hole covers would be provided.

Each position has arm-rests on both sides. The operator's jack is mounted under the left arm-rest, and the supervisor's (service assistant's) jack, if required, under the right arm-rest.

The key panel layout of Type 10A desks is shown in Figure 5. It has a capacity of 46 incoming and 6 outgoing or two-way universal key circuits; or up to 3 additional outgoing circuits (one per strip) can replace up to 6 incoming circuits (2 per strip), for a maximum of 40 incoming circuits with 9 outgoing or two-way circuits. We can supply any combination of circuits up to these ultimates.

Design of Circuit Keys

"Two-forward-motion" type lever keys (see Figure 6) are used in the Universal key circuits, instead of conventional keys with a forward and

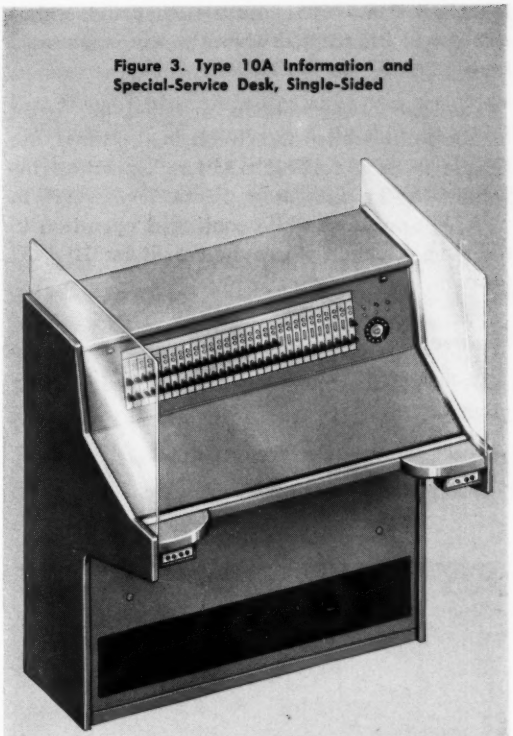


Figure 3. Type 10A Information and Special-Service Desk, Single-Sided

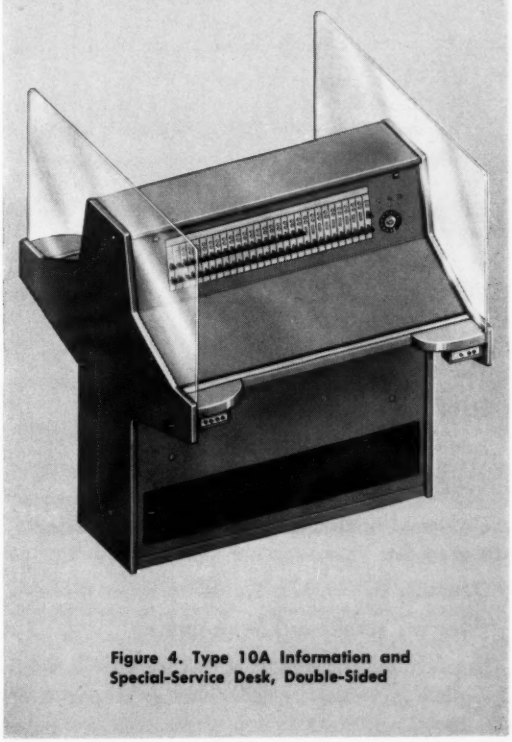


Figure 4. Type 10A Information and Special-Service Desk, Double-Sided

backward throw. This insures that the circuit will not be interrupted when the key is operated from "TALK" to "HOLD".

The two-forward-motion key has an offset handle so that when the circuit is at normal, the handle is in a vertical position. Operating the handle to the first stop places the circuit in "TALK" position, while continued operation in the same direction places the circuit in "HOLD" position.

Features

Universal incoming key circuits are used to provide:

Local Information Trunk Circuits.

Intertoll Information Trunk Circuits.

Some of the more important features of Type 10 Desks are:

As the key circuits are universal, they must be initially assigned to certain specific trunks, and later reassigned to other trunks, if traffic requirements so dictate. In order to provide this flexibility, the key circuits are cabled to the horizontal side of the distributing frame, while the unit-mounted trunk relay equipment is cabled to the vertical side; it is simple to change assignments by merely changing jumpers. As a further aid to a more flexible method of assigning trunks, it is recommended that the Desk be equipped initially with a full complement of key circuits.

"All Trunks Busy" (ATB) and peg-count metering are provided.

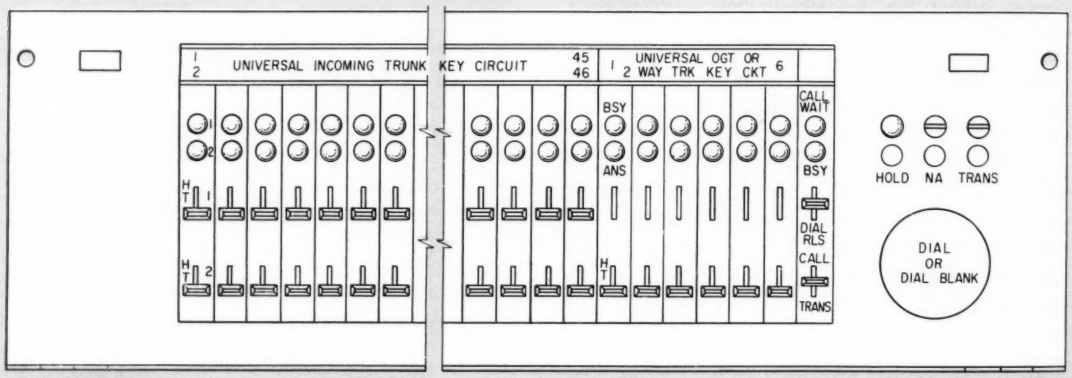


Figure 5. Typical key panel layout of Type 10A Information and Special-Service Desks; variations are described in the text.

Toll Information Trunk Circuits.

Rate and Route Trunk Circuits.

Intercepting Trunk Circuits.

(Night) Repair Trunk Circuits.

Universal outgoing (or two-way) key circuits are used for:

Outgoing or two-way trunks to other desks.

Outgoing trunks to line equipment.

Verification trunks (if repair service is handled on either a full-time or a part-time basis).

Supervisor's (service assistant) circuits permit a supervisor or service assistant to take over a particular incoming call, on a signal from the operator. The call is transferred by a rotary switch that selects the trunk on which the call was received; thus the desk is freed for other calls.

Supervisor's (Service Assistant's) Circuit

The supervisor's circuit of the Type 10 Desk includes a supervisor's jack and a "HOLD" key, which are located under the right arm-rest of the Type 10A Desk, and on the right end of the lock-

rail of the Type 10B. On the right end of the key panel on the Type 10A (or the keyshelf of the Type 10B) is a key escutcheon on which are mounted the "CALL WAIT" lamp, "BSY" (busy) lamp, and a two-way lever key designated "TRANS" and "CALL."

The supervisor's "ANS. & HOLD" lamp is mounted on a pedestal, located so that the lamp signal will be visible from a distance; when required, an audible signal (bell, buzzer, or chime) is mounted within the desk. As previously mentioned, the associated relay equipment is unit-mounted and completely wired at the factory—with a terminal block on which are terminated the leads that are to be cabled to the distributing frame or to the desk. Relay equipment is located on the external relay rack.

When the Information and Special Service operator desires to transfer a call to the supervisor (service assistant), she operates the "TRANS" key. This action lights the busy lamp of the supervisor's circuit in all positions, conditions the circuit so no other operator can transfer another call to the supervisor, sends a "zip" tone to the Information and Special Service operator, flashes the "ANS & HOLD" lamp (on the pedestal), lights the "CALL WAIT" lamp, and provides ring-back tone to the subscriber on the trunk being transferred. Upon receiving the "zip" tone, the Information and Special Service operator may release the "TRANS" key and be free to answer other incoming calls. Should the supervisor (service assistant) fail to answer after a reasonable length of time, the Information and Special Service operator may signal the supervisor (service assistant) audibly by momentarily operating the "CALL" key. This action causes the audible signal to sound.

When the supervisor (service assistant) answers by inserting the plug of her headset into the supervisor's jack, the "CALL WAIT" lamp is extinguished, as an indication to the Information and Special Service operator that the supervisor has taken over the call. The "ANS & HOLD" lamp is also extinguished. The "BSY" lamp at the operator's position remains lighted, as an indication to all operators that the supervisor's circuit is busy.

Should the supervisor desire to temporarily leave the connection, the "HOLD" key is momentarily operated. When the supervisor removes her headset plug from the supervisor's jack the "ANS & HOLD" lamp lights steadily, as a hold indication. When the supervisor returns to the connection the 'ANS & HOLD" lamp is extinguished.

Upon completion of conversation, the supervisor removes the plug of her headset from the supervisor's jack. This releases the circuit, and the "BSY" lamp is extinguished as an indication to all operators that the supervisor's circuit is now available.

On installations of one or two positions, the supervisor (service assistant) circuit would normally not be required, but it can be supplied regardless of the number of positions involved.

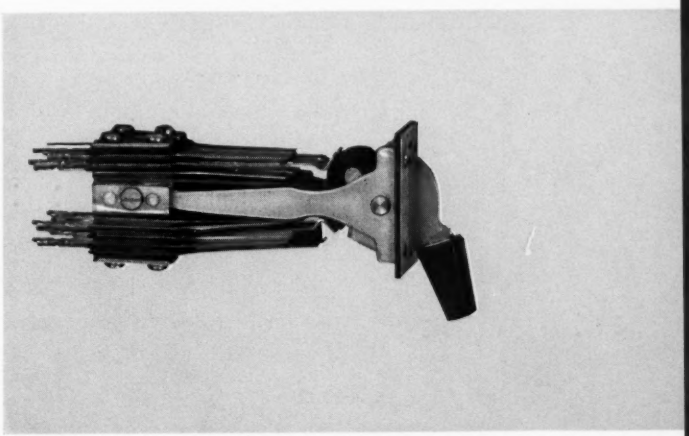


Figure 6. This is one of the "two-forward-motion" type lever keys used in the Universal key circuits instead of conventional keys with forward and backward throw.

Verification Trunk

The verification trunk used on Type 10 Desks is arranged so that when the "VERIF" key is operated, in order to access a line via the verification switch train, the operator's transmitter is shorted. This permits an operator to monitor on a line without the subscriber being aware that the line is being monitored. If it becomes necessary for the Information and Special Service operator to talk to the subscriber, the "VERIF" key is operated forward to the "TALK" position.

Miscellaneous Circuits

The intercepting trunk circuit, when required, is normally part of the switching equipment, and is therefore not furnished with the Type 10 Desk.

Repair Service is, in most cases, handled only on a transferred basis—i.e., after a certain hour the Repair Clerks' Desk is unstaffed and the Repair trunks are transferred to the Information Desk. When Repair Service may be handled on the Type 10 Desk on a full-time basis, the same circuit used for Local Information will be furnished.

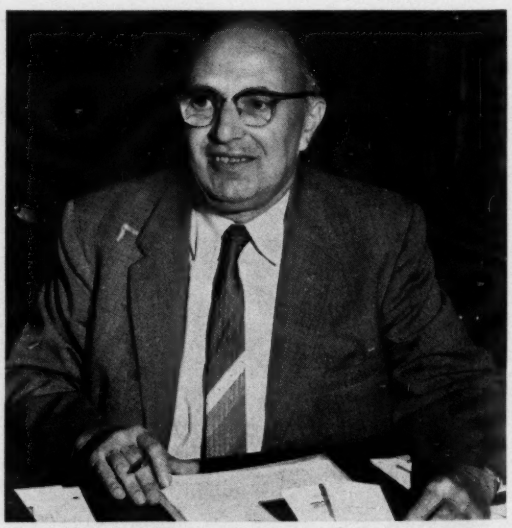
Group Transfer Circuit

A group transfer circuit is provided which can transfer as many of the incoming trunks as required to the toll board during light-load periods when the Information and Special-Service Desk is not staffed. In those cases where an end (Class 5) office provides Information and Special Service locally during part of the day, the trunks may be transferred to the toll board at the toll center (Class 4) office. Those trunks which are not transferred can be busied out by the group transfer circuit.

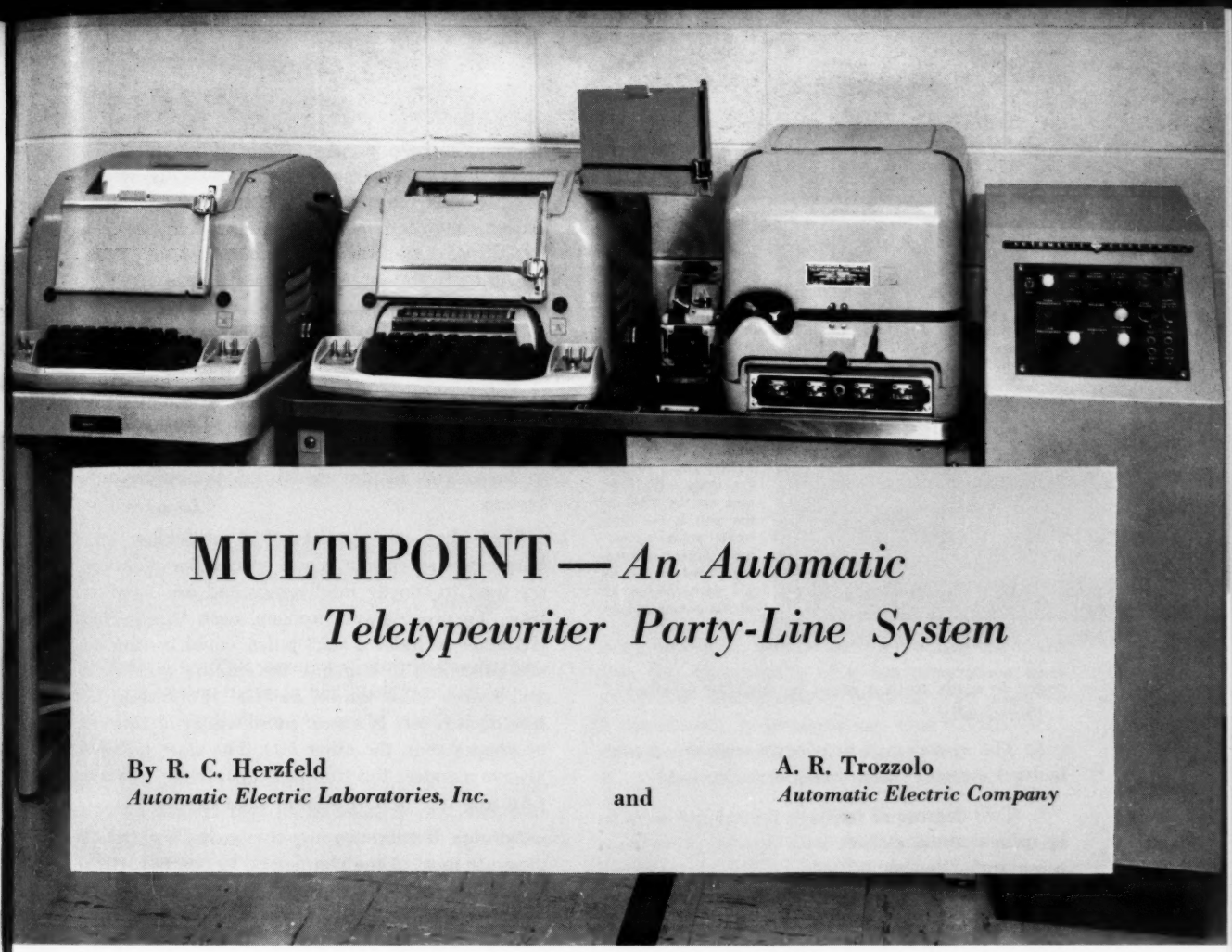
The relay-rack equipment is available to mount on either "10-inch" (1'-7½") or "23-inch" (2'-0⅜") rack. Equipment of each trunk is wired to a self-contained terminal block; the installer simply cables from the distibuting frame to the terminal block, and simple jumper wiring is used to connect the battery, ground, and signal leads from the fuse panel and signal terminal block to the units.

Summary

Type 10 Information and Special-Service Desks replace the Type 3 Desk for use in areas requiring not more than about 50 key circuits. Among the new features they provide are unit-mounted circuit equipment, Class B relays with twin contacts for reduced maintenance and increased reliability, and a supervisor's (service assistant) circuit which permits the supervisor to take over a particular incoming call, on a signal from the operator. All key circuits are universal—can be used indiscriminately for a wide variety of trunk circuits.



Bruno Mandarino started with the Monarch Telephone Manufacturing Co. as an Inspector of Manual Switchboard Equipment on June 20, 1923, when Monarch was a subsidiary of Automatic Electric. He became an engineer with American Electric Co., another subsidiary, and by 1932 had become Final Inspector and Tester. In January, 1941, he joined Automatic Electric's Engineering Department and in February, 1960, he became Supervisor of Manual Equipment Engineering. A registered professional engineer in Illinois, Mr. Mandarino is also a member of the Independent Telephone Pioneers Association and an associate member of the AIEE.



MULTIPOINT—*An Automatic Teletypewriter Party-Line System*

By R. C. Herzfeld
Automatic Electric Laboratories, Inc.

and

A. R. Trozzolo
Automatic Electric Company

Figure 1. A complete Multipoint station layout—left to right, a receiving page printer (on which the keyboard would seldom, if ever, be used), a page printer to monitor sent traffic, a typing reperforator-transmitter, and a Multipoint Station Control Unit.

During recent years, Automatic Electric has developed and installed for the U.S. Army Signal Corps, several large centers where teletypewriter messages are "read" electrically, and automatically switched to the proper destinations. A previous paper* described the equipment and operation of these centers with reference to single-party lines. As in the case of telephone operations, however, economic considerations sometimes dictate the use of party lines, and consequently party-line (Multipoint) operation has been provided for a number of lines in each installation. This paper will describe the equipment (Figure 1) installed at each of the party-line stations to provide this method of operation.

For economical, high-speed use of the lines and the switching equipment, all transmission is by means of prepunched paper tape—not directly from keyboards, which are limited to the speed of a human operator. Starting, then, with tape transmission, the Signal Corps required:

1. Full-duplex operation—that is, any multipoint station must be able to receive a message while it or any other station on the same line is transmitting.

2. Automatic message-numbering — messages from each station must be numbered serially, and failure to send them in proper order must be detected automatically at the center. (Also, mes-

*A Fully Automatic Teletypewriter Switching Center for Military Use, by Leith Johnston and R. C. Stiles, Automatic Electric Technical Journal, April, 1955.

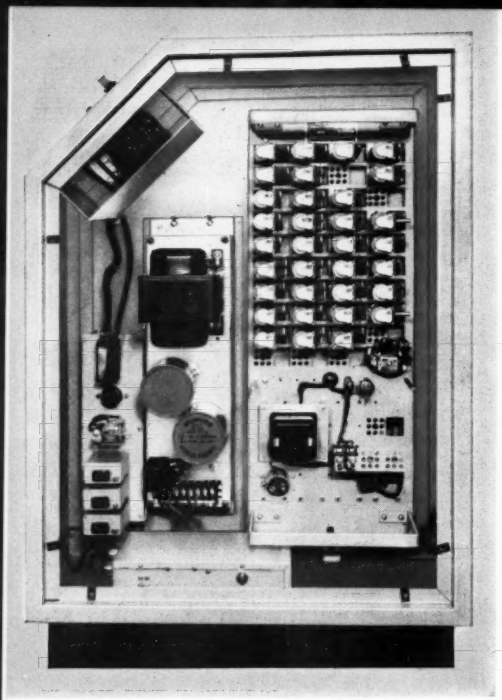


Figure 2. Multipoint Station Control Unit, side view with panel removed, contains all the equipment required to convert a normal single-party station to a Multipoint station except for a conversion switch mounted elsewhere in the Multipoint station. On the right is the relay control unit which includes the receiving polar relay. To the left is the 48-volt power supply for relay operation, and on the floor of the unit is the electronic pulse-regenerator. Fuse-alarm relays and a buzzer are shown to the left of the power supply.

sages *to* each station must be serially numbered, automatically.)

3. The system had to operate with *any* manufacturer's station teletypewriter equipment.

4. Two degrees of message precedence were to be provided: a station with a high-precedence message to send must have not only right-of-way over low-precedence messages, but the ability to automatically "bust" a low-precendence message already started.

5. Within a degree of precedence, stations were to be selected to transmit on an in-turn basis.

6. An operator must be allowed to cancel his own transmitted message, regardless of precedence.

7. The means for conveying supervisory intelligence or controls to the stations could not be allowed to mutilate a message being sent to a station.

8. No extra channels were to be provided for supervisory or control purposes.

9. It was agreed that the station equipment need only recognize the end-of-tape in lieu of an end-of-message sequence. Therefore, only one message per tape is permissible. This prevents monopolizing of the line by one station and allows all stations to be selected to transmit on an in-turn basis.

At the centers now in use, a certain percentage of the channels are provided with multipoint equipment, but where multipoint operation is not desired, they may easily be converted to single-station operation. Multipoint operation requires a multipoint station, and a control unit (Figure 2) at each station to be operated on a multipoint channel.

The Teletypewriter Code

Some discussion of the teletypewriter or Baudot code (Figure 3) is desirable here, since its characteristics present problems which had to be solved in the design of the multipoint system.

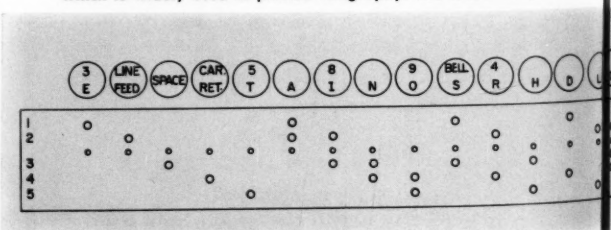
Each character consists of a particular combination of seven *marks* and *spaces*, five of which are used to convey intelligence and are equal in time. To provide synchronism, each transmitted character includes a *start* pulse, equal in time to and preceding in sequence the intelligence *marks* and *spaces* (also known as *bits*). Following the intelligence *bits* is a *stop* pulse, equal in time to or greater than the other *bits*. The *start* pulse is always a *space;* the *stop* pulse is always a *mark*. (An idle line is normally in the *mark* state.)

Special distributors are obviously required to generate most of the characters, but certain characters—M, O, T, V, and LTRS (Letters Shift)—can be transmitted and detected by relay operation. This is because, in each of the above characters, there is only one transition, from *space* to *mark*. As a matter of fact, the letter "O" is approximately 50 per cent *space* and 50 per cent *mark*, in that order. The significance of the above will be seen shortly.

Centralized Control

The first problem to be faced in the design of the system was the means of exerting control over

Figure 3. Baudot Code: The start-stop teletypewriter code which is widely used in printed telegraphy. The letter "O",



all the stations from the central office. The means decided upon was the transmission of pulse trains of varying length, depending on the functions, each pulse being a teletypewriter character. A rotary switch in the Multipoint Station Control Unit is used to count the pulses. The sequences and their functions are as follows:

1. *3-pulse.* This is a special sequence, generated periodically, to put stations "on-line". This sequence must be received by a station after its power has been turned on, before it can send or receive. This sequence differs from all the others in that the pulses do not follow each other at "line" speed.

2. *4-pulse and 5-pulse.* This sequence informs the stations that one of them is to be selected to transmit a low- or high-precedence message, respectively.

3. *6-pulse.* This sequence informs the stations that an end-of-message has been received at the center, and permits a request to transmit by any station.

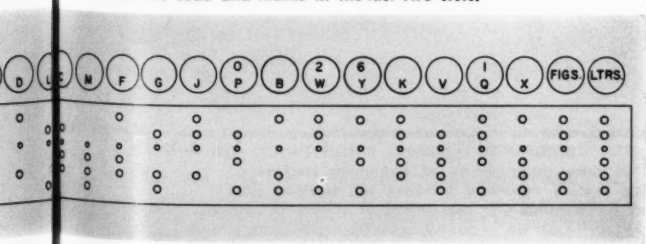
4. *7-pulse.* This sequence informs the transmitting station that its message is canceled, and has the effect of a 6-pulse sequence at all the other stations.

5. *8-pulse.* This sequence informs the stations that one of them is to be selected to receive a message.

6. *9-pulse.* This sequence informs the stations that central-office transmission was finished.

There is also certain information the stations must convey to the central office, and this is done by transmitting LTRS* characters, or by opening the "send" line. LTRS characters are generated, by relays, when a station requests use of the line for transmission of a low-precedence message; this can, of course, be done only when no other station is transmitting. One LTRS character is also generated if a station does not have a message to transmit, when queried by the center.

LTRS consists of marks for all five intelligence bits.



for example, consists of spaces in the first three time slots of the code and *marks* in the last two slots.

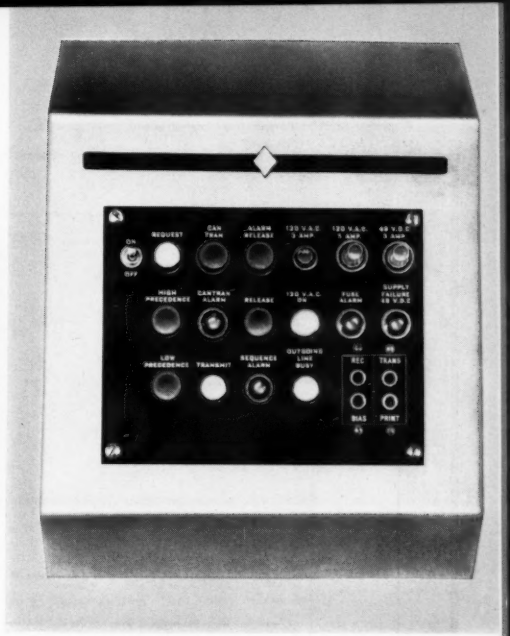


Figure 4. Multipoint Station Control Unit Control Panel: The two precedence buttons on the left are used to initiate "request" codes into the center, but can do so only if there is tape in position to be transmitted, and then only — in the case of low precedence — if the outgoing line is idle.

Opening the send line to the center is used as an indication: First, when a station requests use of the line for transmission of a high-precedence message or when an operator wishes to cancel his message; second, when a station *does* have a message to transmit, when queried.

Operation

Call From a Multipoint Station

Stations are numbered from one to ten (if there are ten stations), and, although all the stations' rotary switches step in unison, each has a relay that is strapped to its own corresponding contact only. A station is queried, therefore, only when its switch is stepped to its own identity contact.

When a station wants to transmit a low-precedence message, an operator places the message tape in the transmitter and operates the low-precedence button (Figure 4). Upon closing the transmitter gate, the station control equipment generates LTRS characters to notify the center that it has a message to transmit. These characters cause the center to send four "O" characters, rapidly, to all stations on the channel;

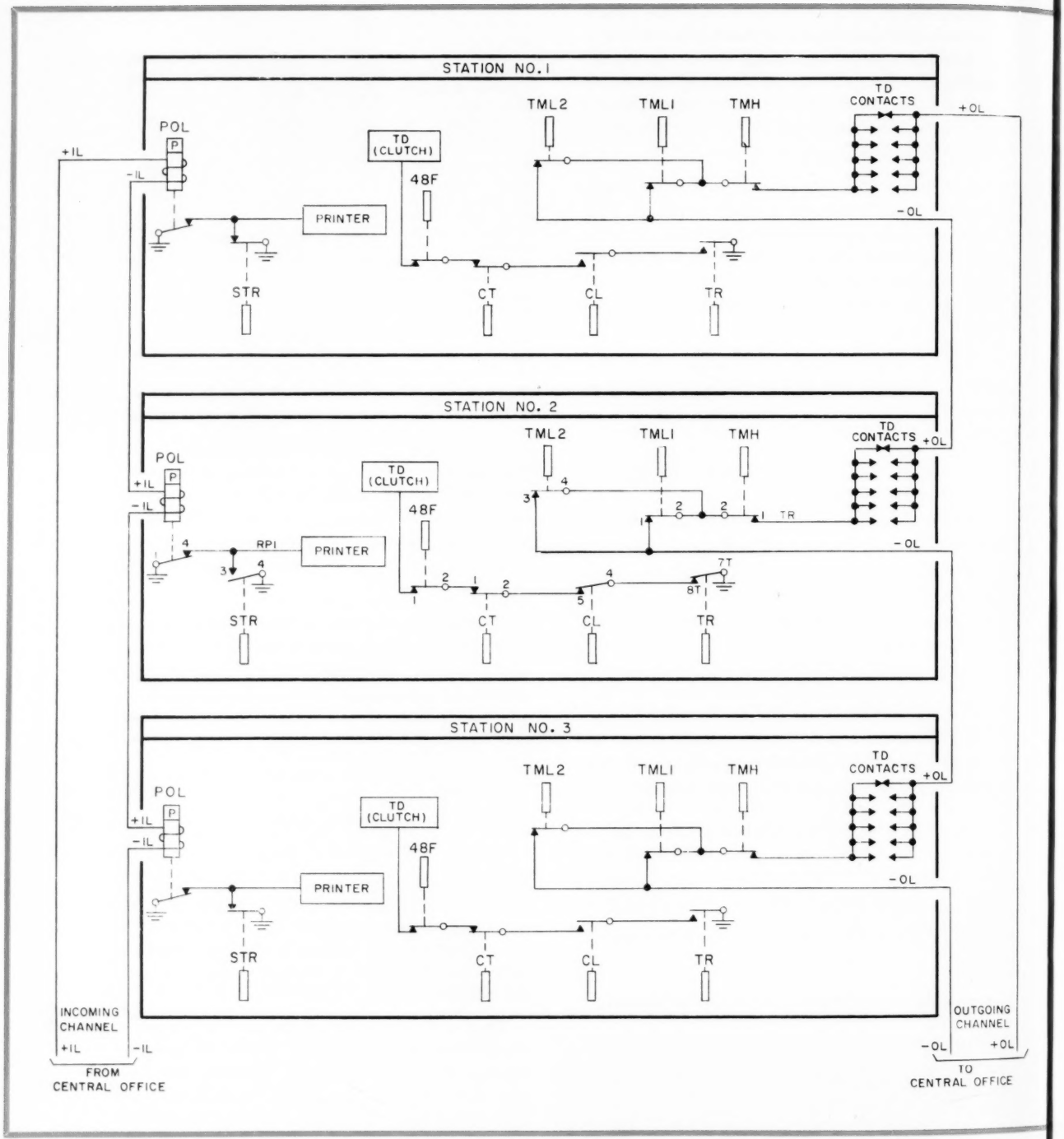


Figure 5. Duplexing: This partial schematic shows the series arrangement of Multipoint stations on a channel. It does not mean that a direct physical link is necessary between the stations since stations can be "looped" off of repeaters which may be in series.

after which a pause is introduced to allow each station's switch to reset. Since the central office remembers which station was the last to transmit, it pulses the line until all stations' switches have stepped past the contact corresponding to that station. (Querying is not recognized by the station during this rapid pulsing.)

When the switches step to the first eligible station, pulsing stops. If the first eligible station does *not* have a message to transmit, it sends a LTRS character to the center. Upon receiving this character, the center transmits another pulse to the channel, and this process continues until the switches step to the contact corresponding to the station which has a message to transmit. This fact is indicated by a line-opening, equivalent in length of time to a teletypewriter cycle, and is recognized at the center as a seizure of the channel by that station. The center now pulses the outgoing channel rapidly, to busy out the unselected stations and restore the switches to normal. The transmitter clutch is then energized and message transmission begins.

Upon receipt of the end-of-message indicator by the incoming reperforator at the center, a 6-pulse sequence is transmitted to the channel. This restores the circuit to essentially the same condition that existed when the station went "on line", and stops the transmitter clutch, if the end-of-tape has not already done so.

Before each message is switched at the center, an Incoming Line tape reader reads the station designation, which must appear on every message transmitted into the center. This done, the message number "comparator" corresponding to the sending station's designation, reads the message number which follows immediately, and compares this number with the one that is supposed to appear. If the numbers do not agree, an alarm is sounded, and further processing of the message is halted. The number stored in the "comparator" is automatically advanced as the end of the message passes the reader.

Call From the Center

When the center has a message to transmit, it sends an 8-pulse sequence; then after a short "reset" pause, it sends a selection sequence that causes the switches to step to the desired station's identity number. Selection is now effected, and the center begins transmission (the message appears on only the selected station's printer, although polar relays at all of the stations actually receive it). When the end-of-message is transmitted, the multipoint station receives a 9-step sequence which returns the station to an "on line" condition.

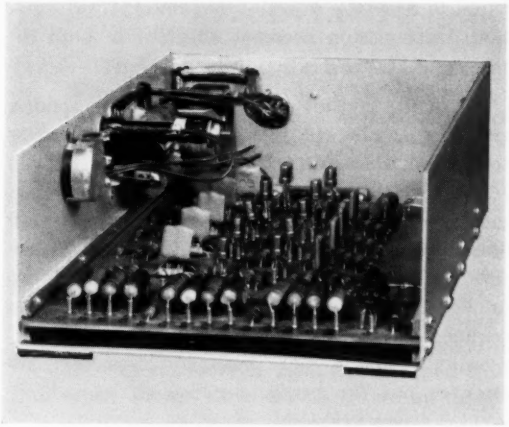


Figure 6. Electronic Pulse Regenerator: This unit, with its printed-wiring board shown here along the bottom, has the purpose of converting teletypewriter characters to single pulses which, in turn, are used to step a rotary switch or to hold operated a slow-releasing relay. The output pulses are of uniform length regardless of the character received.

Each message sent by the center contains a serial number automatically placed in the message heading such that all messages received by each station will be numbered in sequence.

Simultaneous Two-Way Transmission

The foregoing examples illustrate the simplest conditions of multipoint message transmission and reception. It is also necessary, however, to consider more complicated situations which arise frequently. For example, a station may have a message to transmit while it or another station on the line is receiving a message. In this case, the send line (from the station) is pulsed as before, but the center must interrupt its transmission to send back the required sequence. Then transmission is resumed just long enough to allow four or five (depending on precedence) message characters to appear, unmutilated, at the receiving station, and as control pulses at all the stations. Then, as before, the stations are pre-

pared to receive a selection sequence. After selection, transmission becomes effective in both directions (Figure 5).

When the central office is required to send a sequence while sending a message, the latter transmission is stopped just long enough for a relay to release at all the stations. Since such a pause could also occur accidentally, we dare not "blind" the receiving printer at this time. Therefore, we allow it to continue printing until we know that the following characters represent a sequence and not merely a resumption of transmission. This is why message characters are counted out for a sequence, which immeditely creates a new problem.

When the letter "O" was transmitted, it was passed along to the rotary switch where it appeared as a single pulse (see above section on the teletypewriter code). However, when message characters are used for sequences, their form must also be converted to that of a single pulse before the rotary switch recognizes them. For this reason, an electronic pulse regenerator (Figure 6) is provided. This unit looks for a *start* pulse for each character, and disregards the rest of the character until it is well into the *stop* pulse; thus, the regenerator's output is always a single pulse, regardless of the character received. The regenerator is also used to hold operated the relay mentioned in the previous paragraph.

If the message to the center is finished first, the message to the multipoint station is again interrupted to allow transmission of the 6-step sequence. It becomes apparent, then, that this transmission may be interrupted at any time a sequence is required, *except* when the center is transmitting the heading or end-of-message. In this case, all required sequences are stored until the multipoint equipment regains control of the line. Since an interruption of the central office transmission is required to prepare stations for a sequence, it becomes necessary to set time limits on the interruption, so as to avoid stepping the station rotary switches after an interruption —due, for example, to tight tape at the transmitter.

High-Precedence Messages

Since previous discussion has been concerned with low-precedence messages, it now becomes necessary to discuss those of high precedence. For multipoint purposes, the three highest degrees of precedence constitute "high precedence", without discrimination between them; similarly, the lowest three constitute "low precendence". Operation of the "high-precedence" button at the station initiates transmission of a high-precedence request (line opening) and causes the center to send a 5-step sequence, followed by the selection sequence. If a low-precedence message is being transmitted when another station has a high-precedence message to transmit, the center sends a 7-step sequence to the stations and calls on local equipment to transmit a special "cantran" (Cancel Transmission) code to the incoming reperforator. Receipt of the 7-step sequence at the low-precedence station causes an audible and visual alarm signal, and stops the transmitter. The operator at the canceled station then pulls back the tape and attempts to retransmit the message. At this time, selection on a precedence basis occurs, and the "high" station will be selected. The "low" station will be selected only after all high-precedence traffic has been transmitted.

An operator at the multipoint station wishing to cancel his own message, operates the "cantran" button which causes the center to transmit the 7-step sequence. Lamps on a control panel at the multipoint station indicate when a Cancel Transmission sequence has been received, when a message is waiting to be transmitted, when a message is being transmitted from this station, and when a message is being transmitted from another station.

Conclusion

We have described only the equipment installed at the Multipoint stations to provide "party-line" service; associated equipment is required at the switching center, but a description would comprise a paper by itself. Suffice it to say for the present that the switching system described meets rigid and comprehensive specifications of the U.S. Army Signal Corps. It may certainly be expected that the simpler requirements of commercial users would permit considerable simplification in our design, while applying many of the techniques developed for this most comprehensive switching system.

MONOGRAPHS OFFERED FOR SPECIALISTS

For readers of the Technical Journal who are especially interested in specific phases of communication engineering, Automatic Electric offers its series of "Monographs". These papers are prepared by particularly qualified members of Automatic's technical staff, and contain much information that will be of interest and value, within the areas covered.

Monographs now available include:

No. 1—Electronic Switching—by R. C. Stiles. A reprint of the article which appeared in our January, 1959, issue.

No 2—Evolution and Behavior of the "B" Function Relay—by R. B. King. A discussion of this relay (which is basic to the Strowger Automatic system) and of the developments through the years, which have increased its operating range and reliability.

No. 3—Emergency Restriction Line and Trunk Loading Control—by J. C. Colbourne and D. C. Zukausky. A description of facilities available for restricting telephone service in time of disaster or emergencies, so as to assure service to certain key subscribers and personnel.

No. 4—A Practical Method for the Prediction of Relay Operate Time—by R. E. Stoffels. A presentation, with several nomographic charts, of a simple method of calculating the operate time of a relay.

No. 5—Trends in North American Telecommunications—by Dr. I. Molnar. A brief survey of current developments in this area, of interest particularly to telephone engineers and executives outside the United States and Canada.

No. 6—Four-Wire Switching for Inter-City P-A-B-X Dialing—by H. W. Balzer. Considerations in the application of dial operation to telephone networks serving railroads, pipe lines, power companies, etc. Since carrier trunks are extensively used in such networks, four-wire switching makes it possible to retain the inherent one-way character of these facilities, and eliminates the problem of return loss at tandem switching points, for through connections.

No. 7—Strowger Switch Impulsing—by R. B. King. A study of the effect of various subscriber-line conditions and dial speeds on the operation of Strowger switches. Illustrated with nine oscillograms which show the behavior of a typical "A" relay under three different line conditions, and at three dial speeds. The author's comparison of these oscillograms makes it easy to see the effect of changed conditions on switch operation.

To receive copies of any or all of these Monographs, simply address your request to the Editor, Automatic Electric Technical Journal, Northlake, Illinois.

Robert C. Herzfeld studied at the University of Wisconsin and Lehigh University, graduating from Lehigh in June, 1948, with a B.S.E.E. Joining Automatic Electric in June, 1954, after five years with the Chicago and North Western Railway Company's communications and signal department, he has helped develop teletypewriter systems for the U. S. Army Signal Corps and holds a patent for Multipoint systems. He is currently supervising an Industrial Systems Department group of the Laboratories which has designed the teletypewriter switching system soon to be installed in the Chicago Police Department. Mr. Herzfeld is a member of AIEE.

A. Ralph Trozzolo attended Capitol Radio Engineering Institute and Rensselaer Polytechnic Institute. He was associated with Communications Equipment Engineering Company, working with carrier and beacon equipment, until 1947. Joining Automatic Electric, he became Supervisor of Final Switch Testing and Chief Circuit Analyst of Manufacturing Inspection. In 1957, he transferred to the Engineering Department as technical writer on the U. S. Signal Corps teletypewriter manuals, and then became Project Editor of Government Publications. Mr. Trozzolo is now Supervisor of Technical Publications.

Redesigned Push Key and Turn Key Switches

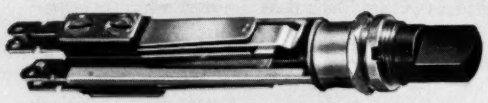


Figure 1. Requiring a minimum of panel mounting space, AE's new compact individual turn key switches have a long trouble-free life. Contact springs are operated by a turn button which extends 5/8" (maximum) from the frame.

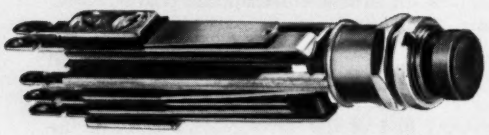


Figure 2. Designed for use where locking-type keys aren't necessary, individual push key switches are operated by a push button which extends 3/16" from the frame.

AE push and turn key switches have been given a "new look" to facilitate their easier, quicker mounting on today's thinner control panels. Although electrical and mechanical operating characteristics remain the same, the method of manufacture has been changed completely. Switch bodies, which were formerly machined from bar stock, are now die cast. They now have integrally-formed collars which are threaded to accept mounting nuts. The old-style lugs which were used when mounting the switches on thick wooden switchboard panels have been eliminated.

An understanding of how the old-style components were mounted is necessary in order to appreciate the advantage of the redesigned push and turn key switches. Formerly, installation procedure included locating and drilling one large hole and two small holes in a control panel. Screws were inserted in each of the small holes from the front of the panel, and spacers were placed over these screws from the back of the panel. Then the component was slipped over the screws and through the large hole. At this point, nuts were started on the screws, and the screws were tightened from in front of the panel (usually a two-man operation).

When installing one of the new style push or turn key switches, a single 17/32" hole is drilled in the panel. The switch is inserted in this hole from the rear of the panel with the hexagonal nut in place. This nut serves as a retainer and also permits frontal exposure adjustment. A castellated nut is then applied from the front of the panel to clamp the switch firmly in place and complete the installation.

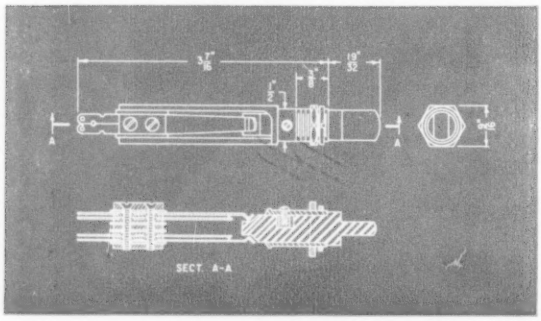
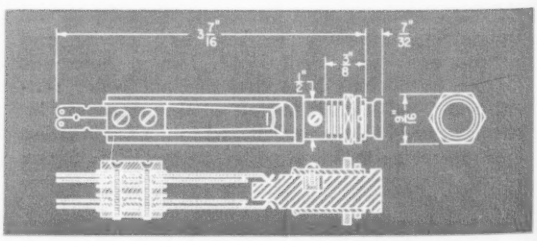



Figure 3. Dimensioned drawings of (left) turn key and (below) push key of new design.